ILLINOIS SUSTAINABLE TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

Annual Report 2013

Contents

Contacts

Champaign Headquarters		(217)	333-8940
Offices	Indoor Climate Research and Training	(217)	265-9489
	Chicago (Oak Brook)	(630)	472-5016
	Godfrey	(618)	466-3806
	Peoria	(217)	300-4199
	Technical Assistance Program	(630)	472-5016
	Governor's Award Program	(630)	605-9904
	Library Services	(217)	333-6892

Photos by: Bart Bartels, Jim Dexter, Nancy Holm, Bob Iverson, Elizabeth Luber, John Marlin, John Mulrow, Seth Rients, Leslie Brian Stauffer, Kelsey Wiles

istc.illinois.edu

Director's Message

Our Business is Sustainable Development in Illinois and Beyond

Today the concept of sustainability has been co-opted by marketers, embraced by special interests, and generally so over used that its meaning has been fragmented and lost.

At ISTC we develop the knowledge and the know-how to contribute to the business case for sustainability in Illinois that can make an impact now. We have built a reputation for pursuing technological advances which can be demonstrated and implemented in the time frame of real business development. Just as importantly, our success has been driven by our process —a systems approach to sustainable growth.

Our focus on economic development motivates us to embrace the TRIPLE BOTTOM LINE—PEOPLE-PLANET-PROFIT. We seek partnerships that enable commerce to reach its fullest resource efficiency without harming future generations' ability to enjoy an ecologically healthy and profitable future.

The list of stakeholders in sustainability is growing longer. Cities and towns, energy producers, manufacturers, transporters, and consumers are increasingly looking for better ways to do their business. ISTC seeks to fill the gaps in connecting these stakeholders, as a reliable third party, to navigate the way to sustainable development. As part of the University of Illinois our capabilites are magnified by the resources of this great creator of essential and applied research.

Sustainability can be a part of the engine that drives economic growth in Illinois. ISTC's three major capabilities (technical assistance, outreach, and research and development) are designed to catalyze economic growth. ISTC embraces its role as the curator of knowledge related to sustainability for the state of Illinois. Our holistic approach that couples sustainability with economic growth is good for the state, good for the nation, and good for the globe.

Sincerely,

Kevin C. O'Brien, Ph.D.
Director, Illinois Sustainable Technology Center

Triple Bottom Line

O'Brien Named ISTC Director


O'Brien

Kevin C. O'Brien, Ph.D., was appointed director of ISTC effective Dec. 2, 2013. Most recently O'Brien served as president of Energy Commercialization, LLC, in the San Francisco Bay Area.

A technology expert and project manager with more than 20 years of experience, O'Brien has managed multi-million-dollar programs related to renewable and sustainable technologies and practices in the U.S. and abroad. His international project experience includes Europe, Middle East, and Asia. Among his professional awards are R&D Magazine's R&D 100 award and a Federal Laboratory Consortium Award for Technology Transfer.

He will lead an organization which for nearly 30 years has advocated and helped enable sustainable practices in industry and other organizations in Illinois. Effective strategies have included applied research, industry and government partnerships, technical assistance, technology demonstrations, and information dissemination.

O'Brien's energy expertise encompasses both the supply side and demand side. He is experienced with projects involving both renewable energy as well as traditional fossil-based fuels. His focus in renewables has been on the development of utility-scale solar projects. As a project developer, he has brought together the necessary technical, regulatory, and financial considerations in order to move solar projects forward. He has also been involved with advisory services to the state of California and utility companies on the reduction of greenhouse gas emissions.

O'Brien led multi-disciplinary teams at Lawrence Livermore National Laboratory in the development of technologies aimed at resolving critical environmental and public health issues such as the contamination of ground water, reduction in greenhouse gas emissions, sustainable development of transportation systems, cost effective water purification for low economic or underdeveloped regions, and the removal of endocrine disruptors from water sources.

O'Brien received his B.S. in Polymer Engineering, and his M.S. and Ph.D. in Macromolecular Engineering at Case Western Reserve University in Ohio.

"Dr. O'Brien's record of effectiveness at bringing together diverse stakeholders for the development and deployment of renewable and sustainable technologies and practices is an excellent fit for ISTC," said Institute Executive Director William Shilts. "His experience in senior management and as a technology innovator will provide leadership to meet the range of sustainable technology challenges our society faces."

"ISTC is well-positioned to be a leader in building collaborative networks between business, government and academia," O'Brien said. "Today sustainable technology is a growing cultural force which we can move forward to maximize economic and environmental benefits."

Associate Director Named State Pollution Prevention Scientist

Nandakishore Rajagopalan has been appointed the Illinois Pollution Prevention Scientist.


Rajagopalan

The new designation was established in August 2013 by the Illinois General Assembly to serve as the authoritative spokesperson on matters of pollution prevention fact and policy for the state.

The Illinois Pollution Prevention Scientist also represents the state on national panels concerned with pollution prevention issues. The appointment was announced on Nov. 22 by Prairie Research Institute Executive Director William Shilts.

Rajagopalan is an associate director at the Illinois Sustainable Technology Center, a division of Prairie Research Institute, where he oversees the Applied Research on Industrial and Environmental Systems (ARIES) group. He has over 20 years of experience in plant operations, green process development, separation technologies, and pollution prevention research.

An active researcher, Rajagopalan holds three U.S. patents and has authored more than 30 peer-reviewed journal articles. His research interests involve the integration of separations research to advance green process development with a special focus on membrane processes.

Acting Director Recognized With Namesake Meeting Space

ISTC's acting director for most of 2013 was thanked and recognized for his service to the Center with the naming of the David L. Thomas Conference Room at its Champaign headquarters.

Thomas was the founding director of ISTC (when it was known as the Hazardous Waste Research and Information Center), which he led for 12 years. He then became director of the Illinois Natural History Survey until his retirement in 2008. Thomas came out of retirement in December 2012 to resume leadership of ISTC as acting director. He stepped down in Dec. 2013 with the naming of a new director. Thomas has been active both nationally and internationally in the area of pollution prevention and sustainable development. He was on the first advisory board and chair of the board of the directors of the National Pollution Prevention Roundtable. He currently is on the Board of Advisors of the Great Rivers Research and Education Center.

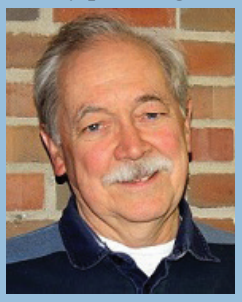
The announcement of the David L. Thomas Conference Room was held during the Center's holiday party. "I was truly overwhelmed by the gifts and the recognition on the conference room," Thomas said. "I feel the Center is poised to reach new levels of excellence."

Thomas

Rose Admitted to ASHRAE College of Fellows

Senior Research Architect William B. Rose was admitted to the College of Fellows of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) in January.

Rose was a practicing architect for 20 years and has been at U of I since 1984, joining ISTC in 2011. His major field of research is heat and moisture in building envelopes—walls, roofs, and foundations—and he has conducted research in indoor air quality associated with weatherization. He is directing the facility planning for the ISTC Weatherization Training Center, under a grant from the U.S. Department of Energy. He is a trainer in building energy efficiency and is currently developing a curriculum in building science.


Rose

He earned his AB at the University of Notre Dame and a M.Arch. at Harvard University.

Peoria Lake Sediments Bring Life to Lake Michigan Shoreline

One of the largest Mud to Parks projects conducted by ISTC involves the relocation of sediment to the former U.S. Steel South Works complex in Chicago. Reclaimed topsoil dredged from Peoria Lake is helping create an 80-acre park along Lake Michigan, reported project head John Marlin. By October newly planted grass was already growing on about 30 acres of the new public green space.

The work extends Chicago's publically owned shoreline by nearly a mile. Meanwhile, Marlin oversaw the moving of 2,400 cubic yards of sediment from the Rice Lake Fish and Wildlife Area to provide reclaimed topsoil for a former coal strip mine in Fulton County that is now a state fish and wildlife area. Mud from Walton Lake in Montgomery County was also excavated and used in various locations by the Litchfield Park District.

Dredging on the Chain O'Lakes and the Fox Waterway to allow recreational boat traffic produced a bonanza of rich topsoil washed downstream from Wisconsin. Over 70,000 cubic yards of this reclaimed topsoil will be used by the Chicago Park District and city of Sterling. Marlin has worked for over a

An extensive Mud to Parks project near Chicago (right) boasted 30 acres of grassy public space by October, using reclaimed topsoil from Peoria Lake. The clean sediment was spread over the area and (inset) was lush with prairie grasses by fall 2013.

decade on efforts to characterize sediment in Illinois water bodies and establish its potential marketability, especially for use in restoration of old industrial sites. His recent work has involved the development of innovative dredging applications and dewatering techniques.

Sediment cores extracted by the Illinois State Water Survey for determining the suitability of river sediments for the Mud to Parks projects have yielded a trove of chronological information about the deposition of sediments and pollutants in the Illinois River and its adjacent backwater lakes in the Peoria Pool. Yonghong Zou and Wei Zheng of ISTC are working with Marlin to analyze the information in the cores to trace sources of the pollutants.

Students Honored for Fresh Ideas in Sustainable Electronics

Old smart phones don't have to be doomed to silence in a drawer or a landfill. According to two winners of the 2013 International Sustainable Electronics Competition the phones can keep track of your cattle, or be tiled together to form large-scale electronic displays.

The winning entries were announced in a ceremony on Thursday, Dec. 5, at ISTC's main office in Champaign. Nine students on four teams from around the world were awarded prizes for their ideas on the beneficial reuse of electronics to prevent e-waste generation.

The Sustainable Electronics Initiative at ISTC has held the annual competition since 2009 to prompt dialogue about the environmental and social impacts of electronics and to contribute to the body of knowledge that advances the practice of environmentally responsible product design, manufacture, use, and disposal for electronics. The competition is open to college and university students and recent graduates.

The winners in the Product Category (items intended for sale) were:

•E-waste Meets Farming, smart phones remanufactured as cow collars (Platinum, $3,000) Michael Van Dord, Swinburne University of Technology, Melbourne, Australia;

•Mion, a multi-purpose dynamo lighting system (Gold, $2,000) Mikenna Tansley, Jiayi Li, Fren Mah, Russell Davidson, and Kapil Vachhar from the University of Alberta, Canada;

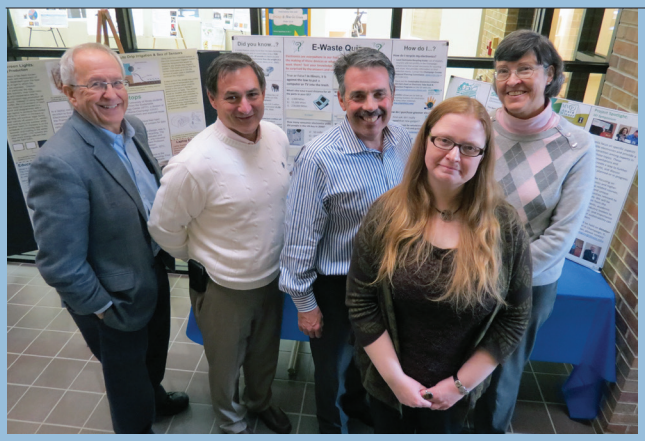
•Cellscreen, a large scale display system made from old phone displays (Silver, $1,000) Sam Johnston, Swinburne University of Technology, Melbourne, Australia.

One platinum level ($3,000) winner was named in the Non-product Category (concepts valuable for artistic, educational, policy, or similar content):

•ENERGENCIA, a children's game encouraging the use of recycled materials and renewable energy concepts by Stephanie Vázquez and Pedro Baños of Instituto Tecnológico y de Estudios Superiores de Monterrey Campus Puebla, Mexico.

"The world must find ways to end the tide of e-waste in the environment," said Craig Boswell, U of I graduate and president of HOBI International, an ISO 14001 certified electronics recycling and asset management company. "This competition, and these brilliant young winners, helps us advance the dialog about environmentally responsible product design, manufacture, use, and disposal of electronics," he added.

Boswell was one of an expert panel of six judges consisting of industry professionals, recycling experts, and the competition founder, William Bullock,



Joining in the winners' ceremony for the International Sustainable Electronics Competition were (L to R) William Bullock, affiliated faculty scientist and U of I professor of Industrial Design, ISTC Director Kevin O'Brien, Joe Verrengia of Arrow Electronics, competition administrator Joy Scrogum and Nancy Holm, ISTC assistant director.

professor of Industrial Design, University of Illinois at Urbana-Champaign. The cash prizes were funded by donations from Arrow Electronics, Professional Field Services, and ISTC.

Other jurors were: Jason Linnell, executive director, National Center of Electronics Recycling; Bill Olson, director, Office of Sustainability and Stewardship, Motorola Mobility, LLC; Lynn Rubinstein, executive director, Northeast Recycling Council; and Kyle Wiens, CEO, iFixt and Dozuki.

Joe Verrengia, director of Corporate Social Responsibility for Arrow Electronics, participated in the ceremony, noting "We understand more than ever now that the useful life of all of those electronics is often very short. We need to come up with something better to deal with that. Competitions and incubators can develop those ideas that hopefully help the world, help Arrow, and maybe be a source of really smart new workers in the future."

The videos of the winning entries are featured on the competition site, ewaste.illinois.edu, the SEI site, sustainelectronics.illinois.edu, and SEI's You Tube channel, youtube.com/seiatistc.

Campus-wide Sustainable Electronics Consortium Formed

On Oct. 2, 2013, ISTC organized a meeting of interested individuals on the U of I campus to discuss the issues involving the environmental and social impacts of electronics and the current relevant policies, education, and research taking place. As a major public university that purchases, uses and disposes of thousands of electronics, we have a duty to address these issues and lead by example to "green up our act," said Joy Scrogum, Sustainable Electronics Initiative co-coordinator.

Scrogum provided an overview of the issues and what ISTC (through its Sustainable Electronics Initiative) and other entities are doing on campus with regard to electronics involving education, research and operations. The group will be examining U of I electronics purchasing policies and possible membership in the State Electronics Challenge.

ISTC, through its Sponsored Research Grant Program, will also be funding future projects on sustainable electronics and e-waste recycling, according to Nancy Holm, SEI co-coordinator. See page 10 for recent projects on a survey of county e-waste collection/recycling and company electronics purchasing practices.

Anyone interested in joining the Sustainable Electronics Campus Consortium can email jscrogum@illinois.edu.

First Midwest Biochar Conference a Success

ISTC, in collaboration with the Illinois Biochar Group (IBG) and the U.S. Department of Agriculture, organized the first Midwest Biochar Conference on June 14, 2013, in Champaign. Over 75 attendees from throughout the U.S. participated in the conference which featured presentations and posters on the latest in biochar research, tours of the ISTC laboratories, and plenty of opportunities for discussion about all aspects of biochar work.

ISTC hosts IBG and maintains its website www.biochar.illinois.edu, which has archives of the presentations from the conference and other IBG past meetings. The IBG has members from throughout the Midwest and encourages research in the production and use of biochar. Biochar is being studied worldwide as a soil amendment to improve soil fertility and nutrient and water holding capacity; for carbon sequestration; and for adsorption of heavy metals and pesticides or other organics. Read more about ISTC's biochar studies on pages 30 and 31.

Illinois Organizations Honored for Valuable Achievements in Environmental Protection

Twenty-seven Illinois companies and organizations were awarded Governor's Sustainability Awards on Oct. 29 in Peoria for significant achievements in protecting the environment, helping sustain the future, and improving the economy.

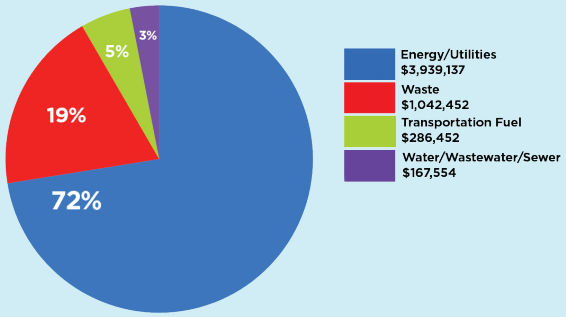
To further acknowledge organizations whose environmental and sustainability efforts are worth noting, a new Honorable Mention category was included this year. Fourteen companies were selected for that honor.

The awards have encouraged environmental excellence through outstanding and innovative sustainability practices since 1987. For a complete list of the honorees, please visit http://www.istc.illinois.edu/info/govs_awards_prev_winners.cfm#2013.

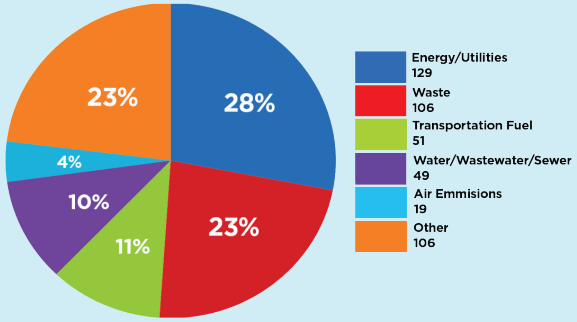
Seven college and university campuses were also recognized at the event by the Illinois Campus Sustainability Compact for setting and meeting environmental goals on their campuses. The Compact Awards are intended to highlight public and private colleges and universities within the State of Illinois for their sustainability efforts. It is a program of the Illinois Green Governments Coordinating Council. For more information on the Campus Sustainability Compact, visit http://www2.illinois.gov/gov/green/Pages/HigherEducation.aspx.

ISTC hired John Mulrow in 2013 as business/industrial sustainability specialist based in its Oak Brook office to maximize marketing effectiveness and industry benefits of the Governor's Award Program. Before joining ISTC, Mulrow was an associate at Cascadia Consulting Group, based in San Jose, CA.

2013 Governor's Award Applicants
Annual Savings Achieved by Category



2013 Governor's Award Applicants
Completed Sustainabilty Projects



One of 15 Accredited U.S. Programs

Indoor Climate Research and Training Achieves National Accreditation

The Indoor Climate Research and Training (ICRT) group received an important distinction this summer when they became the first weatherization training center in Illinois to be awarded accreditation by the Interstate Renewable Energy Council, Inc. The accreditation means individuals passing ICRT's Energy Auditor or Quality Control Inspector courses, including personnel from the state's 35 weatherization assistance agency offices as well as private contractors, "will have met all the requirements to test for the U.S. Department of Energy's Home Energy Professional (HEP) certification," said Paul Francisco, coordinator of the ICRT training program. "Someone who successfully completes our training program can feel confident that he or she has everything they need to pass the HEP examination."

Paul Francisco (left) shows Prairie Research Institute Executive Director William Shilts a new combustion safety studies laboratory under construction at the research and training facility.

There are only 15 accredited weatherization training programs in the U.S., Francisco said. The next goal for ICRT is to seek accreditation for its Retrofit Installers Training Program, he added.

Accreditation of training programs helps drive the effectiveness of the federal Weatherization Assistance Program's (WAP) energy savings, and health and safety goals, in addition to overall cost-effectiveness of the program, Francisco noted. He estimated that the ICRT program trained 300 weatherization agency workers and 300 contractors in Illinois between 2009 and 2013.

In addition to running the training program for the Illinois Home Weatherization Assistance Program, the ICRT group also performs research into issues related to residential energy and indoor air quality. ICRT's current research program includes a partnership with U of I's Department of Civil and Environmental Engineering on a U.S. Environmental Protection Agency project to evaluate indoor and outdoor air quality from the use of solid fuels for heating stoves.

As part of the U.S. Department of Energy's Building America Team, ICRT is studying low-cost measures to reduce residential radon exposure, develop advanced ventilation controls, improve combustion safety methods, and evaluate duct leakage test methods. More extensive radon reduction techniques are being explored as part of a U.S. Department of Housing and Urban Development-funded (HUD) partnership with the National Center for Healthy Housing. ICRT is also involved with the University of Illinois-Chicago in a HUD-funded study on the impact of different ventilation sizing strategies on health outcomes. The group is also conducting a study funded by ASHRAE on garage contaminant transport in homes.

As the polar vortex plunged temperatures south of zero degrees this winter, the New York Times and the Champaign News Gazette busted a myth about frozen water pipes, based on other research at ICRT.

Pipes don't burst when ice expands inside the pipe, explained ISTC Senior Research Architect Bill Rose. Research at ICRT demonstrated that ice forms along the length of a pipe, making water pressure soar. As the blockage grows, so does the water pressure, according to Rose. It is the water pressure that leads to a pipe's failure.

The research suggested practical tips on preventing, and coping with frozen pipes.

For more information about frozen pipe research, visit http://www.nytimes.com/2014/01/09/garden/if-winter-takes-aim-at-the-pipes.html

The Sponsored Research Grant Program at ISTC, with monies from the State's Hazardous Waste Research Fund, has supported over 230 projects since 1985 to advance our knowledge and understanding in the areas of hazardous waste remediation, pollution prevention, alternative energy, water quality and water conservation, as well as other environmental issues of importance to the state. See: istc.illinois.edu/research/. The following 17 projects received funding in 2013:

Electronic Waste—the Downside to Great New Gadgets

The swelling waste stream of electronic devices caused an outright ban for the landfilling of seventeen types of electronics in Illinois in Jan. 2012. Discarded electronics contain a variety of metals and other materials that are both toxic and hazardous to humans as well as plants and animals. A study is underway to evaluate how Illinois' counties are dealing with the ban and what assistance could make the effort more successful.

The Illinois Electronics Products Recycling/Reuse Survey is being conducted by the Champaign County Regional Planning Commission. The work will identify barriers to recycling, the responsibilities of recycling coordinators in each county, and the use of Recycling and Reuse Grants that are available through the Illinois EPA.

All Electronics are not Made, or Unmade, Equal

ISTC sponsored a study of electronics purchasing decisions by businesses which concluded that purchasing decisions are not aided by global efforts to improve electronics design and recycling because many company purchasing agents are not aware of them or believe 'green' choices are more expensive when in reality that is not necessarily true.

The Delta Institute, on behalf of ISTC, surveyed 54 companies and public agencies in Illinois about their electronics purchasing practices. They also conducted interviews as well as live and video presentations. The work was done in consultation with the Green Electronics Council and the University of Illinois Survey Research Laboratory (SRL).

The study found that organizations' purchasing and waste disposal managers need to communicate better. Companies may have robust recycling programs while at the same time not consider recyclability in the purchase of new equipment.

EPEAT® (Electronic Product Environmental Assessment Tool) has been developing sustainable electronics ratings on-line since 2006. Similarly there are two certification programs for credentialing environmentally sound recycling companies. The survey found very low awareness or utilization of these resources by purchasing officers.

The researchers recommended:

• Targeted seminars/meetings for institutional purchasing managers were effective in raising awareness about the benefits of considering eventual disposal of electronics in purchasing decisions. Face-to-face contacts were found to be more effective than video/webinars. Data security standards and reputational liabilities were also noted as particularly effective issues.

• There should be additional points included in the Leadership in Energy and Environmental Design (LEED) certification system for using certified electronics recyclers or purchasing EPEAT products.

• Both EPEAT (purchasing) and certification (recycling) should cross-promote the benefits of a full life-cycle approach to electronics management.

Biochars Investigated for PAH Bioaccessibility

Biochar, pyrolyzed plant residues, has shown promise as a soil amendment because it can improve soil fertility and water retention in some soils. However, there are concerns about certain compounds such as polycyclic aromatic hydrocarbons (PAHs) that can be formed during the production of biochar. Solid waste regulations may limit agricultural applications of biochar if there are high concentrations of PAHs. The U.S. Environmental

Protection Agency (U.S. EPA) has identified 16 PAHs as priority pollutants (seven of which are classified probable human carcinogens).

A study of PAHs in biochar conducted by John Scott of ISTC and Thomas Holm and Michael Machesky of the Illinois State Water Survey examined the effects of pyrolysis temperature and aging on the surface area and PAH content, as well as the bioavailability of the PAHs, for biochar made from corn stover. They found that higher pyrolysis temperatures (≥550° C) were associated with lower PAH production, though the concentrations in all of the corn stover biochars were very low. The research also suggested that the PAH compounds are tightly locked in the carbon matrix of biochar and not likely leachable into the environment. The extent of possible leaching (bioaccessibility) was impossible to measure because of the low concentrations and low extractabilities in the samples. However, by using samples spiked with pyrene, a model PAH compound, the researchers found that for biochar produced at 450° C only 5-10 percent of the added pyrene was bioaccessible, and for biochar made at 550° C and 750° C the bioaccessible fraction was only 1-3 percent.

Illinois Evaluates Switch to Grass for Renewable Energy

ISTC is investigating the characteristics of switchgrass in the production of syn-gas. Switchgrass is ubiquitous around the Prairie State and this collaboration with the Center for Clean Energy Research and Education at Eastern Illinois University (EIU) evaluated it as a feedstock for gasification systems.

This vigorous perennial spreads aggressively and grows in a wide variety of soil conditions. As one of the dominant grasses of the tall grass prairie, it is potentially a robust biological engine for producing renewable fuel, depending on its gasification characteristics.

The work focused on a feedstock of a mixture of wood chips and pelletized switchgrass. This was compared in experiments with wood pellets as a baseline.

In general the material performed well, passing cleanly through the gasifier with good mixing of the feedstocks, acceptable ash and tar formation, and favorable hydrogen production and temperature ranges. The experiments, however, revealed a significant amount of clinkers (solid residue or slag caused by melting and agglomeration of ashes), presenting a continuing challenge for the use of switchgrass as a feedstock in these systems. Clinkers are labor intensive to remove and can lead to explosions if allowed to accumulate.

The Illinois EPA periodically holds household hazardous waste collection events in central and southern Illinois counties.

Household Hazardous Waste Collection Improvements

Household hazardous waste (HHW) is an continuing area of concern that is being addressed in a study to assess current disposal practices and help develop optimum strategies for their disposal. Batteries, paints, solvents, oils, pesticides, and chemicals that are all too easy to toss in the trash or pour down the drain. Improper disposal risks environmental pollution and threats to human health.

The project, funded by the Lumpkin Family Foundation and ISTC, is led by Susan Monte, recycling coordinator for the Champaign Country Regional Planning Commission, and is expected to result in the development of a strategy for effective, alternative HHW collection options for the selected seven-county area in East Central Illinois. Following a situational analysis the study will continue to identify local partners, develop collaborations, and build grassroots support to develop and implement more convenient options. The work is also hoping to produce templates of options which would be repeatable in other parts of Illinois.

Graduate student Wei Zhang made clay fired bricks using various proportions of biomass gasification ash to find the optimum formula for cohesion and strength.

Gasification Ash as a Building Block to Sustainability

Vinod Patel, B.K. Sharma, and Wei Zhang of ISTC and Peter Liu and Mori Toosi of Eastern Illinois University are studying the sustainable use of biomass gasification ash in the manufacture of fired clay bricks and concrete blocks.

They are investigating ways to use gasification solid waste in fired clay bricks and concrete masonry without the need for any pre-treatment. Disposal of the by-product ash of biomass gasification can be a significant part of a system's operating costs.

They reported that ash waste can replace approximately 10-20 percent of more expensive (and greenhouse gas emitting) components without sacrificing strength of the final product. Such fired clay bricks and concrete blocks are also at least 10 percent lighter than conventional products. The preliminary techno-economic analysis of utilizing 1,500 tons of biomass gasification ash to make building materials indicated that substituting 20 percent ash for cement to make concrete products can save around $257,714 annually and reduce 1,336 tons of CO_2 emission. The substitution of 10 percent ash for clay and shale to make fired clay bricks can save around $120,000 annually.

Other Funded Research

- **Antioxidants from Wood-Derived Pyrolyzates (Bio-Oils)** HWR12-220 (See p. 22).
- **Biochar Supercapacitors for Energy Storage** (See p. 30).
- **Examining Low-Value Waste Products for Fuel** (See p. 20-21).
- **Fate of Pharmaceutical and Personal Care Products in Irrigated Wastewater Effluent** HWR12-223 (See p. 25).
- **On the Feasibility of Establishing a Saline Aquaculture Industry in Illinois** HWR12-228 (See p. 18).
- **Performance Validation and Demonstration of In-Stream Hydrokinetic Power for Wastewater Treatment Plants** (See p. 17).
- **Preliminary Investigation of PPCPs in Wastewater at Champaign and Urbana Wastewater Treatment Plants** (See p. 26).
- **Simultaneously Strengthening of Carbon Sequestration and Heavy Metals Immobilization in Soil via Biochar Modification** (See p. 31).
- **Spatial and Source Apportionment Analysis of Contaminants in the Illinois River Sediments** (See p. 7).
- **Uptake and Accumulation of Pharmaceuticals and Hormones in Vegetables after Irrigation with Reused Water** (See p. 36).
- **Use of Effluent Water in Cellulosic Ethanol Production** HWR12-227 (See p. 22).

Senior Research Chemist Wei Zheng measured the uptake of contaminants in lettuce and tomatoes irrigated with wastewater by using a hydroponic system.

Aquapod Developed as a Sustainable Source of Drinking Water

Despite living on a planet mostly covered with water, humans face critical water shortages due to pollution, overuse, population growth, natural disasters, and climate change. The need is so great that providing access to clean water was named one of grand challenges for engineering for the 21st century by the U.S. National Academy of Engineering.

ISTC's latest patent application describes a new approach to desalinization which reduces environmental impacts which have undermined other water treatment technologies.

Dubbed Aquapod, the process is a new approach to applying forward osmosis (FO) to desalinization by adding a polymer to the system to speed the production of fresh water. ISTC Associate Director Nandakishore Rajagopalan is leading the team to develop the technology.

The characteristics of the Aquapod technology suggest the system could not only be used in everyday life where there are continuous water shortages but could also be workable in a portable size that would be valuable to quickly provide water in a disaster or refuge zone. FO is already used in "hydration bags," a product for campers and soldiers to purify contaminated surface water or recycle urine in an emergency.

If successful Aquapod would solve one of the two major barriers to moving FO technology forward—non-corrosive, non-toxic, and stable draw solutions that generate high osmotic pressure yet are easily separated from water.

Forward osmosis has been investigated for a number of years as a low-energy method to solve our fresh water shortage. Instead of applying +60 atmospheres of pressure to push water through a filter (as in RO, reverse osmosis), forward osmosis takes advantage of the natural osmotic pressure differential to move liquid through a semi-permeable membrane.

ISTC's innovative Aquapod process adds an inorganic salt during the process to raise the osmotic pressure on one side of the salt filtering membrane. The increased osmotic pressure of the 'draw solution' pulls seawater through the membrane, leaving much of the salt behind. A polymer is added to assist in water extraction from the draw solution and is recycled.

All desalinated waters are expensive to produce when compared to naturally occurring fresh water sources on land. Energy is the key variable that determines the viability of desalinization technologies. Commercial desalinization plants in Australia, the Middle East and elsewhere around the world use reverse osmosis in large scale, capital intensive applications that require a lot of energy.

Ragagopalan's goal is to scale up the Aquapod (FO) process to achieve lower capital and operating costs. To scale up the process, Rajagopalan's team is making its own filters with a machine that produces a very thin filament of polymer which is spun onto a rotating wheel. The surface matrix of the filters is then coated with polyamide. Filters constructed in this way help overcome another major barrier to commercial FO desalinization—concentration polarization. Filters that maintain high flux and good salt rejection characteristics will greatly increase the promise of FO desalination, Rajagopalan explained.

Riding a Rising Tide of Sustainable Business

One Man's Vision Spreads Goal of Cleaner Commerce

Matt Bochantin loves to save money. He calls every incremental cost savings at his Eaton B-Line business manufacturing plant—a "kiss".

His career has been built partly on the aggressive use of new technologies to cut waste, save money and make his company more competitive. For this he has had the close assistance of the Technology Assistance Program (TAP) at ISTC.

Shortly after becoming the Highland, Illinois plant's facilities engineering manager in 1994, Bochantin was paid a visit by engineers of the TAP program. "They were in the area and stopped by and we had a chit-chat," said Bochantin.

The TAP program, a free consultation service of ISTC, uses early adopters like Bochantin to test and demonstrate processes, creating real-world examples that help speed dispersion of new technologies statewide. Similarly, Bochantin has learned to use the TAP engineers to brainstorm new projects and help validate his own ideas to his superiors.

See One Man's Vision on page 19

Model Technical Assistance Program Puts Sustainability in Crosshairs of Successful Industry

A home-grown technical assistance model for greening Illinois industry has proved its practical value over the past 15 years.

Developed at ISTC during the late 1990s, the ADOP2T (Accelerated Diffusion of Pollution Prevention Technologies) model was a new idea to provide intensive technical assistance that would allow companies to put their factory toes in the water of green industry before diving completely into extensive changes in their processes. It works by identifying best practices and executing brief demonstrations and extended pilot trials of pollution prevention practices and technologies on-site at facilities. These pilot trials provide the site-specific information required to influence companies in making decisions to adopt these technologies where economically and technically feasible.

ADOP2T was founded on time-tested innovation diffusion principles that have been applied to innovations in industries as diverse as agriculture and communications. Its fundamental goal is to turn business leaders into champions for greener industry.

"The ADOP2T approach has been a great success in our region," according to Christine Anderson, U.S. Environmental Protection Agency Pollution Prevention Coordinator for Region 5 (covering six industrial states: Illinois, Indiana, Ohio, Michigan, Minnesota, and Wisconsin). "During the on-site trial period, businesses get to observe the environmental and economic benefits these technologies provide to their business," Anderson explained. "Once businesses witness how these technologies can reduce their environmental footprint, while also saving them money, then they are much more likely to invest in, and integrate, these technologies into their operations for the long-term."

The fact is there is a lot of money to be made in going green. During FY 2013, an intensive effort lead by ISTC staff focused on suburban Chicago's DuPage County businesses and saved $335,674 by reducing waste, optimizing material and resource usage, and cutting electricity use by 2,482,292 kWh and natural gas by 58,428 therms. Direct environmental benefits included less waste of all sorts. For instance, water usage was cut by 1.8 million gallons and 6,800 gallons of wastewater were eliminated. Greenhouse gas reductions of 2,421 metric tons of CO_2 were also achieved.

"The way things have evolved, companies have gone away from regulatory resistance to a green business paradigm," stated Deb Jacobson, manager of ISTC's Technical Assistance Program (TAP). "Lean manufacturing is the major motivation, but I would say probably 95 percent of the manufacturers out there at least have environmental benefits on their radar screens."

Tim Lindsey, global director of Sustainable Development for Caterpillar Inc., who developed the ADOP2T model while leading TAP in the late 1990s, agreed that the profit motive is not the only driver for industry to adopt sustainable technologies. "It is true that there is a continuous struggle with respect to value, bottom line and investments—so sustainability projects are competing with others." The distinction between cause and effect in any company's commitment to sustainability can be impossible to sort out, he explained. "But one of the big drivers is reputation so top management is heavily vested in reputation—your brand—and they will go to great lengths to protect and enhance it."

The new approach to technical assistance came out of Lindsey's doctoral research in urban and

Technical assistance at ISTC goes deeper than generic programs, partnering with municipalities and industries to cut waste and save money from a full process perspective, helping Illinoians lighten their footprint on the environment.

Christine Anderson, U.S. EPA Pollution Prevention Coordinator, chats with ISTC's Dan Springman during a pilot training program in Chicago where the Center's technical experts helped colleagues from across EPA's Region 5.

regional planning at U of I by adapting the science of innovation diffusion.

"It was baffling to us when we worked with these companies and made recommendations, with significant advantages to their operation, but when we checked back with them they hadn't done it," Lindsey said. "Other times our suggestions had little benefit to the company, but they were implemented." Piloting the technology on-site makes a huge difference in adoption of new practices.

The financial benefits that come from greener industry are only the beginning of implanting best practices in industry leaders, Lindsey said. You also need to demonstrate that the new ideas are compatible with existing processes. They must not be perceived as overly complex. New processes should be demonstrated and even tried on a limited or interim basis before full commitment.

TAP programs in Kentucky and Minnesota have also adopted the Illinois model – enjoying similar benefits. Cindy McComas, retired director of Minnesota Technical Assistance Program at the University of Minnesota, adopted the principles of ADOP2T through a National Pollution Prevention Roundtable initiative funded by EPA. "We felt we could hit the ground running more quickly by promoting new technologies that would make industry more efficient," she said. The new approach increased the implementation rate by industry from 20 percent to more than 50 percent.

"The whole technical assistance field is usually a generic approach," McComas explained. "ADOP2T gives the effort a lot more resources and is more of a long-term commitment." The state was able to build good relationships with industries, particularly by partnering with companies on planning for future environmental regulations.

As evidence of their continued leadership in the pollution prevention and sustainability fields, ISTC's Technical Assistance Program was awarded a 2013 MVP2 award by the National Pollution Prevention Roundtable in Washington D.C. They were honored for their successful technical assistance program which delivers services to populations in small, rural communities in parts of the state which have had little access to conservation or pollution prevention programs.

Called ICORE (Illinois Conservation Of Resources and Energy), the program saved Illinois businesses and governments more than $6 million in energy and water savings, as well as hazardous waste prevention. It was funded by U.S. EPA Region 5.

"ISTC have distinguished themselves through their approach to pollution prevention implementation."

Christine Anderson, U.S. EPA Pollution Prevention Coordinator, Region 5

The Center also completed year-long technical assistance programs called the Waste to Profit (WTP) and E3 (Economy, Energy and Environment) Assistance Program for urban DuPage County manufacturing and industrial facilities. That program was also funded by U.S. EPA Region 5 and involved a partnership between ISTC's Technical Assistance Program, ComEd's Technical Services Group and the Illinois Manufacturing Excellence Center (IMEC), which is the National Institute of Standards and Technology's manufacturing extension program of Illinois. E3 is a national initiative supported by six federal agencies to promote sustainability in the manufacturing sector.

WTP is a regional by-product synergy project that actively connects businesses together to utilize wastes and under-valued resources so that the materials can be used as feedstock for others.

Small Turbines Investigated for Portable Energy Generation

The latest Technical Assistance Program technology demonstration is designed to see if small, portable turbines (pico-turbines) can cost-effectively produce electricity from moving water along streams and rivers. The first successful installation has already been achieved at Chicago's Stickney Water Reclamation Plant, where a "drop-in" in-stream hydrokinetic turbine was placed in the effluent flow distribution box.

These turbines allow the emission-free generation of energy without environmental impact in rivers, channels, spillways, and irrigation systems. They are also considered low-cost since they do not require the construction of dams.

The prototype turbine, supplied by Hydrovolts of Seattle WA, quickly revved up to its rated output of 1.5 kW. This emerging technology has the potential to generate 50 kW at Stickney. If fully proven and adopted, the project will help Stickney meet its goal of becoming energy neutral in 10 years.

A small turbine installed in the wier tank at the Stickney Water Reclamation Plant near Chicago is the latest technology demonstration of the Technical Assistance Program. Success of the project would help the wastewater treatment plant to meet is goal of becoming energy neutral.

Investigating a Saline Aquaculture Industry for Illinois

The Illinois-Indiana Sea Grant Program and ISTC funded an initial study which demonstrated that an inland saltwater fish farming industry is possible using Illinois' vast underground saltwater aquifers.

Saltwater aquifers underlie nearly the entire state. The use of this water resource and also reuse of saline wastewater are of interest to ISTC researchers.

Environmental Engineer Rupa Ganguli and Associate Director Kishore Rajagopalan teamed with researchers at Southern Illinois University-Carbondale and Purdue University-West Lafayette to conduct the study.

In this project, striped bass were grown in synthetic saline water prepared to be similar to known concentrations of salts, excluding trace minerals, in the Ironton-Galesville aquifer and compared to controls of seawater. The fish grew in synthetic saline water the same as in seawater over a 24-week period. The researchers noted the fish did appear more 'excitable' in the Illinois saline water formulation, but their stress hormone levels were unchanged.

The effect of trace mineral and contaminant levels in the Ironton-Galesville formation still need to be analyzed. If they are found to impact fish growth, pretreatment would be necessary before using this water in commercial farming.

One impetus for the research is the Midwest Geological Sequestration Consortium carbon sequestration project which is pumping one million tons of CO_2 underground at Decatur, IL. If scaled up to commercial levels, this may require the displacement of saline water as a method of pressure relief. This highly saline effluent could be potentially useful as a resource for marine aquaculture.

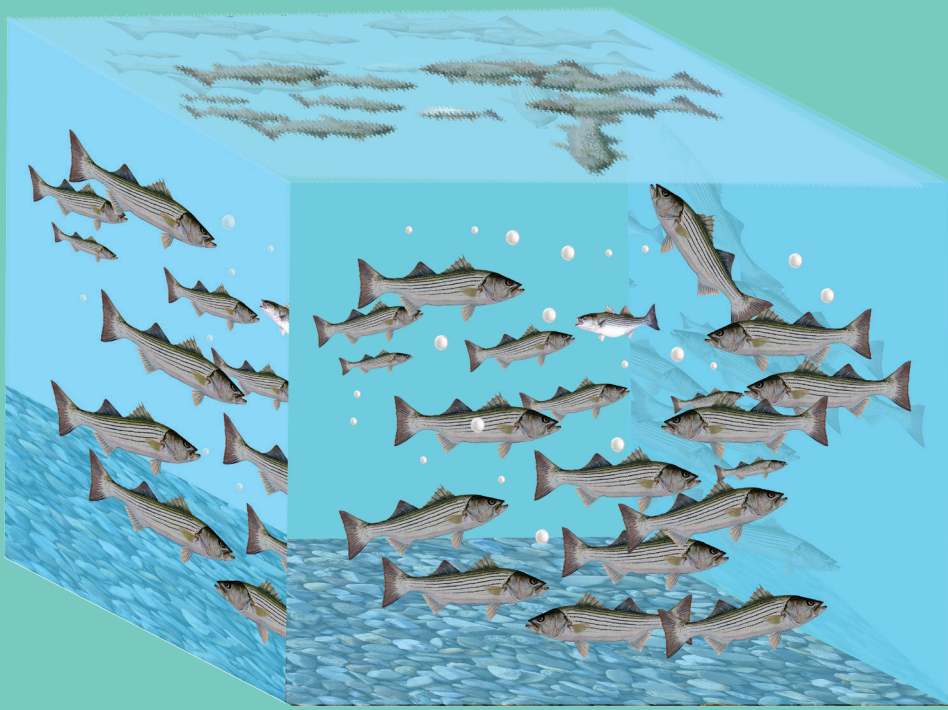
Freshwater fish farming is a growing industry in Illinois producing hybrid striped bass, largemouth bass, channel catfish, tilapia, and carp totaling more than 360,000 pounds and worth over $1.5 million so a marine aquaculture industry would enhance that.

According to the U.S. Department of Agriculture, the United States imports 84 percent of its seafood – about half wild caught and half from aquaculture. The Chicago seafood market is the fifth largest in the U.S., importing nearly all of the saltwater fish consumed there from outside the state.

Another source of saline water for marine aquaculture could be industrial effluents, the researchers stated. Power plants and ethanol plants are among many industries that routinely desalinate water to make it fit for industrial use. The highly saline wastewater is currently transported for disposal but likely could be available at low cost to use in marine aquaculture.

The researchers recommended that the growing of other saltwater species besides striped bass be investigated. Inland shrimp production should especially be studied since most of the nation's $9 billion seafood trade deficit (U.S. Department of Commerce, 2011) in seafood is attributable to shrimp.

Saline Aquaculture Opportunity in Illinois
Imports (Chicago): 99 percent
Trade Deficit: $10 billion



One Man's Vision Spreads Goal of Cleaner Commerce

Continued from page 14

"Back then I was under the gun to cut energy costs," he said. It was the beginning of a relationship of give and take that has helped Bochantin to become a heavy hitter with his bosses. Now his duties have expanded from managing just the Highland facility to traveling to B-Line plants nationwide to deliver lessons in cost cutting by adopting environmentally beneficial technologies. Recently he has moved to a divisional role, responsible for operations at seven facilities.

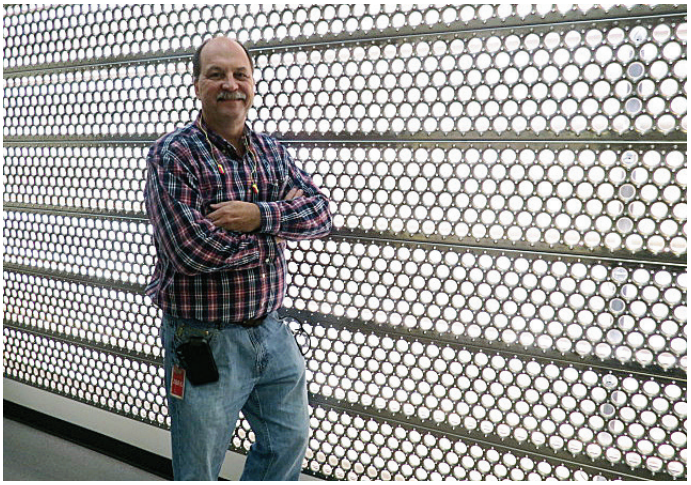
Eaton's B-Line business makes metal supports and channels for cabling, as well as racks and enclosures for cabling and telecommunications systems. Their processes involve milling metal, painting and electroplating. They use large quantities of water, paint, solvents, and coolants.

"To my knowledge we were the first in the industry to retrofit lighting with LEDs." That was back when LEDs were expensive upgrades, but energy savings recouped the investment in a year and a half. "Most people don't realize that the real savings are reduced air conditioning costs," he explained. "Electric lighting is only part of the story," he added.

The company was also among the first to apply ultrafiltration, early advocated by ISTC's Kishore Rajagopalan, a leading expert in the use of the technology for industrial effluents. Ultrafiltration membranes selectively remove molecules, depending on the size of the membrane pores. Bochantin once discharged the paint-laced water from his paint line about nine times a year. By using ultrafiltration, he has been able to recover the paint and recycle the water, meaning he replaces the water in the system less than once a year.

That translated to $44,268 a year in reduced costs—more than one million gallons (78 percent) less water used and wastewater generated, a seven percent cut in paint purchases, and 32 percent reduction in chemical use. The paint vendor was so concerned about their reduced sales they visited the plant, thinking business was bad. "Business was great, we had just cut our waste," Bochantin said.

Now Bochantin has the confidence of his superiors that his 'projects' will bring significant improvements



Matt Bochantin, working with ISTC's technical assistance professionals, has become a champion of reducing costs with sustainable manufacturing processes.

to Eaton's bottom line and environmental footprint in their communities. But it wasn't always so. Early in his career there was skepticism about his environmental innovations. "The guys from TAP provided me with the third-party validation I needed to get approvals."

Even the small projects now have Bochantin talking like he is trying to stop a burglary. "If I have a dollar of energy coming into the building, I want to know how it is used and where it goes. Most individuals will look at the efficiency of exhaust fans, but the real equation is larger than that. We've pumped that air and conditioned that air, so we are not just going to send it back out the vents." He even saved money switching to recyclable fabric booms for soaking up spills on the shop floor.

Bochantin gives a lot of credit to the TAP program. "We've worked hand-in-hand on the projects and with lots of brainstorming back and forth to share technologies and best practices. It's a relationship that has made a difference in Eaton being a good neighbor in our communities and a good steward to help the environment."

Wastes Explored as a Flexible Source of Energy

Americans throw away about 100 billion plastic shopping bags each year, according to the Worldwatch Institute. The U.S. Environmental Protection Agency reports that only about 13 percent are recycled. The rest of the bags end up in landfills or escape to the wild, blowing across the landscape and entering waterways.

The waste bags are made of polyethylene which is produced from fossil fuel. Polyethylene is used to make everything from hard hats to hula hoops, but it is light-weight plastic bags that tend to escape into the environment and are difficult to recycle.

An ISTC research team led by B.K. Sharma, senior research scientist, and including Research Chemist Dheeptha Murali and Process Chemist Jennifer Deluhery are working to convert these waste bags and other hard-to-recycle plastics into diesel, natural gas and other useful petroleum products.

Their approach involves heating the bags in an oxygen-free chamber, a process called pyrolysis, said Sharma. The conversion produces significantly more energy than it requires and results in transportation fuels – diesel, for example – that can be blended with existing ultra-low-sulfur diesels and bio-diesels. Other products, such as natural gas, naphtha (a solvent), gasoline, waxes as well as lubricating oils such as engine oil and hydraulic oil also can be obtained from the plastic shopping bags. The process yields one gallon of fuel for every eight pounds of bags (approximately 800 bags). "You can get only 50-55 percent fuel from the distillation of petroleum crude oil," Sharma said. "But since this plastic is made from petroleum in the first place, we can recover almost 80 percent fuel from it through distillation."

"This diesel mixture had an equivalent energy content, a higher cetane number (a measure of the combustion quality of diesel requiring compression ignition) and better lubricity than ultra-low-sulfur diesel," he said. "A mixture of two distillate fractions, providing an equivalent of U.S. diesel #2, met all of the specifications" required of other diesel fuels in use today – after addition of an antioxidant, Sharma said.

Crude produced from plastic grocery bags at ISTC has been distilled into a range of fractions that meet all criteria for use as drop-in fuels.

The researchers were able to blend up to 30 percent of their plastic-derived diesel into regular ultra-low sulfur diesel, "and found no compatibility problems with bio-diesel," Sharma said. He added that he foresees a time after the depletion of petroleum sources when old landfills become mines of valuable plastics and other raw materials.

"It's perfect," he said. "We can just use it as a drop-in fuel in the ultra-low-sulfur diesel without the need for any changes." The Center has partnered with Argonne National Laboratories for engine testing for emissions and combustion efficiency of the fuels.

Previous studies have used pyrolysis to convert plastic bags into crude oil. Sharma's team took the research further, however, by fractionating the crude oil into different petroleum products and separating the diesel fractions to see if they complied with national standards for ultra-low-sulfur diesel and bio-diesel fuels. Their work was published in the journal Fuel Processing Technology and was reported in news outlets around the world.

If a pure stream of one million tons of plastic bags could be diverted from landfills, a scaled-up process

Earth911.com estimates one trillion plastic grocery bags are produced each year worldwide. The U.S. EPA reports only 13 percent are recycled in this country.

could turn it in to almost four million barrels of crude worth almost $400 million, Sharma noted..

The recovery of energy from hard-to-recycle plastics has been a broad area of interest at ISTC. In addition to shopping bags and plastic marine waste, the lab is looking at plastic types 2, 4 and 5. That makes plastic bottle caps, yogurt cups, Styrofoam, disposable cups, plates, cutlery, and jewel CD cases potential feedstocks for the pyrolysis unit.

This research was supported by the Environmental Research and Education Foundation and ISTC's Sponsored Research Grant Program.

Plant Waste Pursued as Recycled Source of Bio-Oils

ISTC research on the production of oils has also recently evaluated different agricultural and waste feedstocks for the type and amount of bio-oils produced. So far pyrolysis products from used coffee grounds, algae, hardwood (birch), corn stover, and *Miscanthus* have been studied. Future work will include other woods like willow.

(left to right) Deeptha Murali, B.K. Sharma and Jennifer Deluhery are part of the team studying fuel production from hard-to-recycle plastics.

For the fuel processing study, the research team also included Bryan Moser, Karl Vermillion and Kenneth Doll of the USDA National Center for Agricultural Utilization Research in Peoria, IL and Kishore Rajagopalan of ISTC.

Non-Petroleum Source of Antioxidants Sought in Wood

ISTC investigations reveal that the stability of plastic-derived oils and bio-oils needs to be improved. This attribute is especially important in the case of distributed processing of plastics where the produced crude oil may have to be stored for aggregation prior to further processing and blending.

ISTC is currently looking at waste wood as a renewable source of high-value compounds like antioxidants which can increase stability of oils.

Since antiquity people have used wood smoke to retard contamination and preserve food. Now a multi-year ISTC collaboration with the U of I Department of Natural Resources & Environmental Sciences is analyzing products from the pyrolysis of wood waste to search for a renewable source of antioxidants to replace synthetic petroleum-derived compounds BHT and BHA.

Woods contain simple and complex phenols. Softwoods contain up to 35 percent lignin, a complex phenolic polymer. Hardwoods, which can contain 20-29 percent lignin, are much richer in guaiacyl-syringyl lignins which are predicted to lead to superior antioxidants when pyrolyzed (a thermo-chemical conversion process).

Industry produces millions of tons of wood processing waste (like bark and sawdust) every year. The resulting oil from pyrolysis of these wastes is a dark-colored brew that includes a complex mixture of oxygenated organic compounds including ketones, furans, phenols, and acids. The phenols and other aromatic chemicals represent a much higher value product from bio-oil than than does producing bio-diesel from this wood waste.

Grasses and Wastewater Studied for Renewable Fuel

The federal mandate to replace 20 percent of gasoline use with renewable fuel sources has led to a massive U.S. commitment to corn ethanol production. The difficulty of choosing between cheap and plentiful fuel, or cheap and plentiful food, could disappear if technology can make the use of non-food plants economically competitive. Another criticism of ethanol production is that it uses large quantities of potable water.

Roadside 'crops,' like the (left to right) Illinois Bundleflower, Prairie Dropseed, Prairie Cordgrass, and Big Bluestem, are being evaluated as feedstocks for bio-fuel.

Center researchers led by Kishore Ragagopalan along with Professor Vijay Singh and students from the U of I's Agricultural and Biological Engineering program have been working on reducing the potable water usage by comparing the use of three different types of effluent water in cellulosic ethanol production.

Filtered and unfiltered effluent from Decatur and Bloomington-Normal wastewater treatment plants was used. Filtered wastewater produced as much glucose and ethanol as the control. The presence of ions in the effluent actually increased the ethanol yield. Unfiltered Decatur effluent produced less glucose but the ethanol production was similar to the other samples, suggesting the enzymes might still be active producing glucose during fermentation.

On the non-food feedstocks side, the Center is working with CABER and the Illinois Plant Breeding Center to examine polysaccharides and bio-oil yields of different *Miscanthus* varieties. The perennial grass *Miscanthus x giganteus* has previously been identified by many researchers as a strong candidate to replace corn as a feedstock.

The Center is also working with the Illinois Department of Transportation to evaluate the prairie plant species planted along Illinois highways as a source of energy feedstocks. In addition to diverting plant clippings from landfills, ethanol production from the plants would provide revenue for road maintenance.

Water — Our Most ~~Abundant~~ Precious Resource

Better Water Measurement Reveals Emerging Areas of Contamination Concern

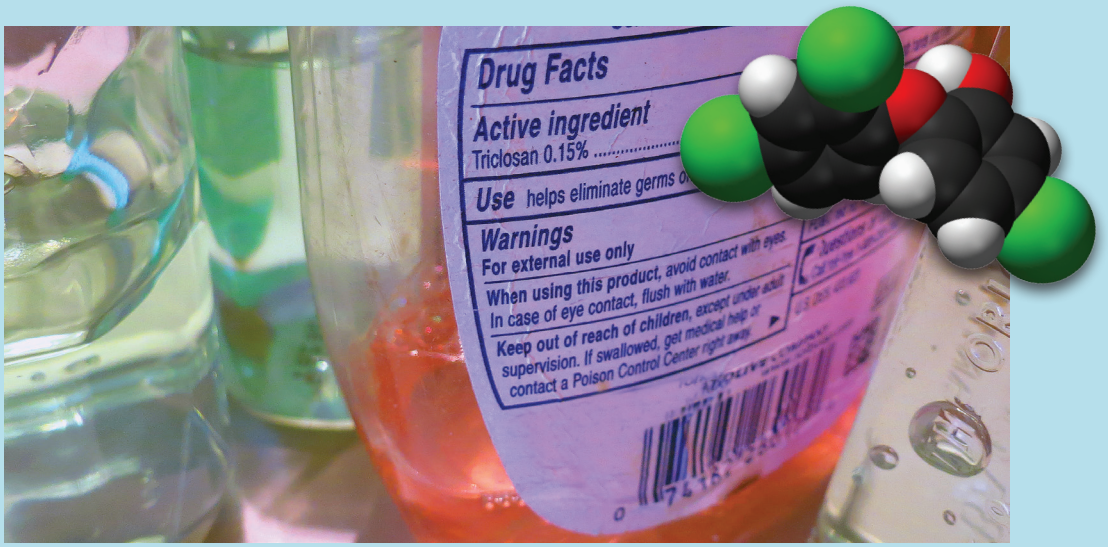
Water—water quality, water conservation, and water reuse—is a core focus of ISTC activities. A number of our projects are investigating an emerging area of concern, the occurrence of hormones and pharmaceuticals and personal care products (PPCPs) in the aquatic environment including groundwater and watersheds.

Over the past decade, animal hormones from livestock and poultry manure and PPCPs from sewage effluents have been identified by the U.S. EPA as contaminants of emerging concern. Little is known about these contaminants' impact on the environment or on human health.

As newer technologies have improved the detection of lower and lower levels of chemical contaminants, it is now possible to investigate these environmental interactions for the first time.

Humans and animals excrete natural hormones and unmetabolized medicines into the waste stream when they are not fully absorbed. Similarly, hygiene use adds personal care products into the wastewater treatment system. Wastewater treatment plants and concentrated animal feeding operations (CAFOs) are identified to be point sources for discharging these emerging contaminants.

Microbeads are in hundreds of beauty products. In the environment many creatures mistake them for food.



Following years of scrutiny the FDA has instructed manufacturers to demonstrate that the anti-bacterial compound Triclosan is safe and more effective than soap.

Anti-Bacterial Resistance is Confirmed for Triclosan

One of the most high profile cases of concern involving PPCPs in the environment is that of Triclosan, a anti-bacterial compound widely used in soaps, cosmetics, clothing, and many other products.

ISTC Senior Chemist John Scott, working with colleagues at Loyola University Chicago and the Cary institute of Ecosystem Studies in Millbrook, New York, were among the first to demonstrate that Triclosan does trigger bacterial resistance in aquatic ecosystems.

This work, funded by ISTC's Sponsored Research Grant Program, confirmed the presence of Triclosan in stream sediments in the Chicago metropolitan region and other suburban areas. Sources for Triclosan contamination included domestic wastewater traced to broken sewer pipes and releases of untreated wastewater during high rainfall events. Low-dose chronic contamination also occurred when wastewater treatment did not completely remove Triclosan from their effluents.

Their field surveys indicated Triclosan concentrations increased as they went from less to more urbanized areas. They found a significant correlation between the concentration of Triclosan on the stream bottom and Triclosan-resistant bacteria present. Controlled experiments in an artificial stream confirmed the compound triggers resistance and shifts the diversity and composition of bacterial communities. The consequences of altered bacterial communities have not been determined.

The results of the study were published in the July issue of Environmental Science and Technology a journal of the American Chemical Society. Last summer multinational consumer goods giant Proctor and Gamble also announced that it would phase out Triclosan from its products. And in December, due to growing concerns expressed by the public, environmental groups, and medical associations about the wide-spread use of Triclosan and possible environmental and human health effects, the U.S. Food and Drug Administration told manufacturers of antibacterial soaps and body washes to demonstrate within the next year that their products are both safe and effective in preventing illnesses more than plain soap. The agency also recently addressed the use of antimicrobials in livestock feed, saying their frequent use prompted "concerns about the contribution of this practice to increasing the ability of bacteria and other microbes to resist the effects of a drug" and they are holding public hearings on that issue.

Impact of Industrial-scale Food Production Investigated

The fate and transport of hormones and antibiotics which are widely used in the meat and poultry industries are also being investigated by ISTC researchers.

Today an estimated 96 percent of concentrated animal feeding operations (CAFOs) use growth hormones and/or antibiotics during production. The U.S. Department of Agriculture (USDA) funded the project to trace runoff and leaching of animal

Field sampling is being used to investigate how efficiently current wastewater treatment facilities are removing prescriptions and personal care products (PPCPs).

hormones and veterinary pharmaceuticals associated with land application of CAFO wastewater and manure. The project also evaluated the effectiveness of management strategies to reduce loading of hormone and antibiotic contaminants from CAFOs into the environment.

The researchers examined levels of 17α-estradiol, 17b-estradiol and estrone in water, manure-contaminated wastewater and soil. They also conducted laboratory experiments to investigate aerobic and anaerobic degradation of six steroid hormones and two antibiotics. The results indicated that anaerobic conditions prevented or slowed the breakdown of hormone contaminants.

Therefore, the team concluded that increasing the residence time of wastewater in CAFO lagoons or using aerobic tanks may be economical and efficient methods to degrade hormone and antibiotic contaminants and thus reduce their loads to the environment.

Batch soil experiments in the laboratory found that the antibiotic ceftiofur showed a relatively higher sorption capacity than florfenicol in soils amended with animal manure. The sorption capacities of florfenicol in manure-amended soils were less than those in non-amended soils, indicating manure-borne colloids can facilitate leaching of this contaminant to groundwater through soil.

Field monitoring of bodies of water surrounding agricultural fields receiving CAFO waste found that hormone contaminants were seldom detected in well water samples, but they were observed in some subsurface tile-drained water samples, especially during effluent irrigation and storm events.

New Analytical Methods Used to Investigate Rural Lagoons

Additionally, the efficiency of rural wastewater treatment plants (WWTPs) to remove PPCPs is being investigated by ISTC.

In the rural areas of the U.S., domestic wastewater is typically treated in a series of aerated lagoons which are discharged into local watersheds. ISTC is interested in whether this water could be used to irrigate energy crops.

Wei Zheng and colleagues at the Illinois State Water Survey developed a method to analyze 13 PPCPs and eight steroid hormones. They concluded that the removal efficiency of PPCPs in the rural lagoon systems is comparable to most municipal WWPTs at certain times, ranging from 88 to 100 percent. The exception was carbamazepine (an anticonvulsant and mood-stabilizing drug used primarily in the treatment of epilepsy and bipolar disorder) which was quite often detected in effluents and watersheds.

The study found large seasonal variations in PPCP contaminant removal by WWTPs, influenced by variables such as heavy rain, drought, and changes in ambient temperature. Under cold temperatures, for instance, samples exhibited higher concentrations of PPCPs by one to two orders of magnitude.

Effluents for Irrigation Examined for PPCPs

The USDA study provided a valuable baseline for background PPCP contamination in soils. Though there may be some contaminants present in the rural wastewater effluent, the use of effluent from aerated lagoons to irrigate farm land could provide a beneficial use of the nutrients—nitrogen and phosphorous—present in the wastewater, enhancing soil fertility and crop production while potentially reducing any contaminants before the water works its way to receiving streams. Researchers from ISTC, the Illinois State Water Survey, and Illinois State University took advantage of a new irrigation project in the central Illinois town of Lexington to begin to evaluate the occurrence of nutrients and PPCPs in fields receiving effluents.

The study also allowed the researchers to determine characteristics of cropland soil that may impact PPCP transport and to better understand the sorption and desorption capabilities of field soils in Lexington.

Possible uptake of contaminants by plants irrigated with wastewater effluent is also an important consideration. Zheng conducted studies to track the uptake of these emerging contaminants in vegetables grown in contaminated water. In that study, Zheng set up a hydroponic system for growing tomatoes and lettuce using various concentrations of PPCPs and hormones. Analysis is still underway assessing concentrations in roots, stems, leaves, and fruit of the plants.

Broad Collaboration Supports Medicine Collection

ISTC is involved with a new program in Champaign Country which collects old and unwanted drugs to keep them out of landfills, or to keep them from being flushed down the toilet.

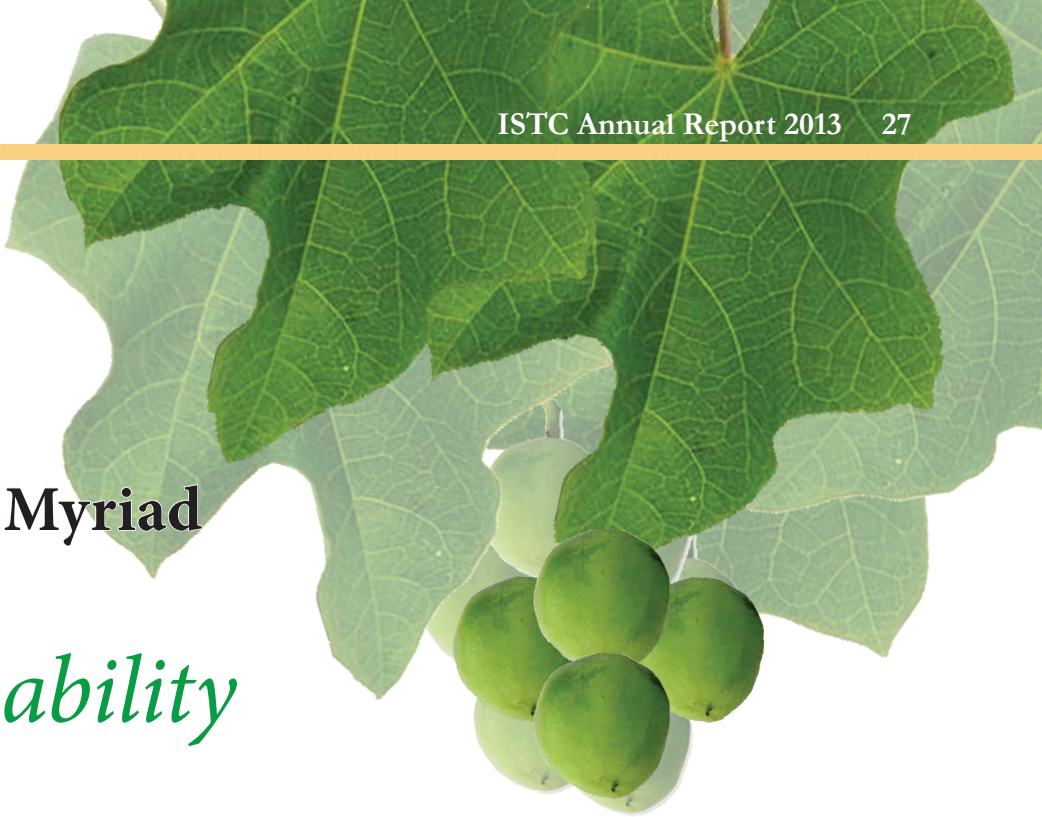
The goals of the program are to reduce accidental poisonings of children and pets, prevent drug diversion and abuse, and limit environmental impacts from storage or improper disposal of unwanted or expired medicines. This is the first pharmaceutical take-back program in Champaign County to be able to collect controlled substances. Prescription, and over-the-counter medicines, as well as veterinary pharmaceuticals will be accepted.

Locked collection boxes were placed in police department lobbies of the county and city of Champaign, Urbana, and at the University of Illinois which are available at all hours. The drugs remain in police custody until they are incinerated.

The program is a partnership between ISTC, the Illinois-Indiana Sea Grant, Champaign Police Department, Urbana Police Department, University of Illinois Police Department, Champaign County Sheriff's Office, the National Prescription Pill and Drug Disposal Program, the cities of Champaign and Urbana, Illinois American Water, the University of Illinois Student Sustainability Committee, Champaign County Regional Planning Commission, Champaign-Urbana Public Health Department, WCIA and the Prairie Rivers Network.

As part of our collaboration on this C-U take-back program, ISTC is investigating the concentrations and occurrence of 16 PPCPs and hormones at the Champaign and Urbana waterwater treatment plants (WWTPs) to establish baseline information for the area. Tertiary wastewater treatment plants are the dominant

purification technology in urban areas and they have previously been found to be quite effective at removing some of the common PPCPs but not others. Most WWTPs were not designed to specifically handle these types of contaminants. This study, which began in 2013, is being conducted by a team of Wei Zheng, Nancy Holm, Elizabeth Luber, Kelsey Wiles, and Dheeptha Murali. It is determining how the different stages of tertiary treatment affect the chemical structure and occurrence of PPCPs, hormones, and micro-plastic pollution in the effluent and in the surrounding aquatic environment. The study is being done over a 24-month period to examine the seasonality of the concentrations detected in the influent and effluent.



Haiti Adventure Brings Home the Myriad Difficulties of *True Sustainability*

It seemed like God's gift to true sustainability in 2007.

The journal Nature had just reported that the inedible fruit of the *Jatropha curcas* tree met European technical standards for bio-fuel.

The good news for those interested in transportation fuels was that the oils extracted from the seeds performed well for power, efficiency and emissions. *Jatropha* was reported even richer in oil than soybeans, rapeseed and sunflower. For someone interested in bringing jobs and energy to Haiti, the Western Hemisphere's poorest nation, the news was even better.

Jatropha is a semi-evergreen tree in the same family as poinsettias. It is a perennial, grows like a weed in dry climates on marginal lands. Its resists pests and its roots provide help against soil erosion.

That same year, Partner for People and Place (peopleandplace.org), a U.S. non-profit organization, established Jatropha Projenou (Our Community *Jatropha* Project) in northeast Haiti to create a sustainable system based on the crop for subsistence farmers. ISTC, and its environmental engineer Joe Pickowitz, signed on to provide technical expertise to create the processing system that could turn *Jatropha* into bio-diesel.

For Jatropha Projenou co-founder Kathleen Robbins, the best news about the promising bio-fuel crop is that it offered a chance to demonstrate the success of a tightly integrated, completely sustainable system.

A Land of Plenty of Little

The slave revolt more than two centuries ago that led to the first independent black nation contributed to the ruin of the lush, wealthy French slavery-based colony of Saint Domingue. There followed international economic boycott, forced reparations, black-mulatto unrest, U.S. invasion, dictatorship, corruption, profiteering, deforestation, embargoes, soil erosion, and widespread, desperate poverty.

According to recent estimates, more than 80 percent of the population of Haiti lives in poverty with half of the population in abject poverty. Forty percent of Haitians depend on farming, mostly on tiny subsistence plots. Unemployment is 40 percent. Underemployment is also endemic with a generally unskilled labor force, most of which do not have formal jobs. For all of that misery, the majority of the economic activity and foreign aid only benefits the Port-au-Prince region which was laid waste by the 2010 earthquake.

For those living in northern Haiti, and its northeast department which surrounds Jatropha Projenou (JP), there is little electricity, little running water, little infrastructure at all that might attract capital.

"They need jobs, they need opportunity," said Robbins. A cash bio-fuel crop was particularly well-suited for this situation, she said. The twin goals of sustainable agriculture—food security and income generation—set the stage for this effort. Genus *Jatropha* fruit is inedible and most varieties are toxic; JP has planted both toxic and non-toxic varieties. Farmers can plant food crops such as beans between the rows of *Jatropha*, aerating the soil and providing weed control while also providing a wind break for their plantings.

Jatropha already seemed to be the silver bullet to defeat the odds long-fixed against rural Haitians when cellphone entrepreneur Denis O'Brien promised to buy all of the bio-fuel that JP could produce.

The case was promising, outcomes were synergistic and complimentary. Farmers can grow both food and a cash crop that the co-op can turn into bio-diesel to sell for use in electric generators and transportation. Production of a home-grown fuel source lessens the flow of Haitian capital to foreign suppliers. The remaining biomass after oil removal from the toxic variety is currently recycled as a soil enhancement and the non-toxic variety is being tested as animal feed. *Jatropha* farming is labor-intensive, particularly

Joe Pickowitz runs a batch of *Jatropha* through the bio-fuel reactor. The saying over his shoulder reads, "Mister Jatropha."

field preparation and harvest. It was a vision of a sustainable, stable economy that can form the basis for long-term investment and growth.

Poison Pill or Pig Chow

ISTC Senior Analytical Chemist John Scott has also studied *Jatropha* as part of the Haiti project. He has been particularly fascinated with its phorbol esters content, one of three compounds that make *Jatropha* varieties toxic (also hydrocyanic acid and curcin).

He sees great potential in the use of phorbol esters as a natural pesticide. China and India has shown research interest in the compound but little work has been done elsewhere, he said. The substance might represent a sustainable weapon against insect-borne diseases. For instance, 80 percent of estimated malaria cases occurred in Ethiopia, India, Indonesia, and Pakistan. (World Malaria Report 2013) Three of those nations lie in the general latitudes where *Jatropha* occurs.

"I love making *Jatropha* oil in the lab," Scott said. "It makes the whole lab smell like sesame oil." The odor of the *Jatropha* cake also reminds him of Snickers candy, so the palatability of the material as animal feed seems promising, he added. A study of four varieties of seed from Mexico showed that levels of all essential amino acids (except lycine) were higher than the Food and Agriculture Organization/World Health Organization reference pattern. (J. Martinez-Herrera et al./Food Chemistry 96 (2006) 80-89) "It is very rich in protein; it is a fascinating plant," Scott explained.

Efforts on the island to hybridize the phorbol esters out of the native Haitian trees have yet to be

verified in Scott's lab, he said. Sustainable systems tend to protect an area's biodiversity by focusing on indigenous plants rather than monocropping of non-toxic, imported strains as is being pursued in India.

Another problem for true sustainable agriculture in this case is that it is not easy to characterize phorbol esters. No source of reference material exists, so Scott has successfully used a compound used in cancer research that has a similar enough structure to fill in. Detecting phorbol esters also requires expensive equipment not common in Haiti.

A method was needed to distinguish between toxic and non-toxic seed cake for use as animal feeds, Scott explained. He has worked with colleagues at the U of I to propose a simple field test for toxicity by putting scored seeds in a glass jar with small insects.

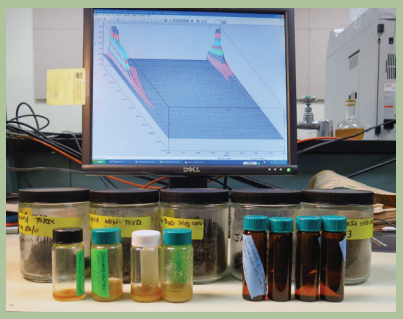
A Five-Year Mission

In 2010 the enterprise harvested its first truck load of *Jatropha* fruit, enough that it was turned into fuel to run their production generators and tested in their tractor. The sustainable enterprise seemed to be coming into its own.

But subsequent harvests of the full-grown *Jatropha* trees did not increase as anticipated. The delivery of seeds was far below the assumptions in their business plan. The weather played a role. Northern Haiti is prone to intermittent rainfall (in part caused by de-forestation) but over the past three years, periods of drought have been punctuated by floods and devastating storms.

Although *Jatropha* had created much excitement worldwide, it turns out that high-yield production only occurs in good soil and with reasonable rainfall, conditions in which fuel competes with food. Continuing research has suggested that *Jatropha* can survive with as little as 9.8 inches of annual rainfall. It flowers and bears fruit starting at 23.6 inches. The optimum range for fuel productions is now estimated at 39.3-59 inches of rain. Normal rainfall in northeast Haiti is 27.5-31.5 inches per year.

What has been learned through this Haiti experience? Robbins suggests there is still much work to be done but an answer is in sight. A Dec 25, 2013 New York Times article (http://www.nytimes.com/2013/12/25/business/energy-environment/start-up-makes-gains-turning-jatropha-bush-into-biofuel.html?_r=1&) "Start-UP Uses Plant Seeds for a Bio-fuel") confirms that plant science could supply the answer to this dilemma.



ISTC's John Scott has analyzed and characterized a range of fuels and waxes produced from *Jatropha*.

Jatropha Projenou depends on local wild species of a plant that may have more than 10,000 genotypes. The future of *Jatropha* bio-energy seems to lie in the science of genomics and plant sciences, Robbins said. Some commercial ventures are showing increased yields with hybrid plants. "The next chapter in the *Jatropha* story may be plant science," Robbins said.

Yet too much has been achieved to give up on Jatropha Projenou, Pickowitz, Scott and Robbins agree. They have overcome a number of difficulties—most critical the trust of local farmers—to walk away now. They have succeeded in building a system capable of producing 75 gallon batches of bio-fuel every two days. Plans are going forward to add solar energy and other improvements to the apparatus.

For now not sustainable fuel, but the production of soap, has at last brought jobs and profit to Haiti. Glycerin is a by-product of the bio-diesel process and this soap is selling around the north shore. Hospital sales along with tourist sales are helping move the venture towards a break-even point, according to Robbins. A serious cholera epidemic on the island has made hand washing a high priority. Additional soap sales to cruise ship passengers and guests at high-end hotels have buoyed Jatropha Projenou.

Despite the challenges, Jatropha Projenou has been successful in getting the attention of local growers. The group engaged two Haitian university agronomists who were able to help them become well established with the local farmers. Previously, the sisal plantation was the major employer in the area and with its closing, people had to resort to subsistence farming and fishing to survive. With the arrival of JP into the area, they have been able to substantially increase food production while supplementing their income with the sale of *Jatropha* seeds. ISTC will continue to assist the bio-diesel efforts.

Red cedar biochar shown to be an effective and environmentally friendly supercapacitor

Clean Power Takes a New Turn

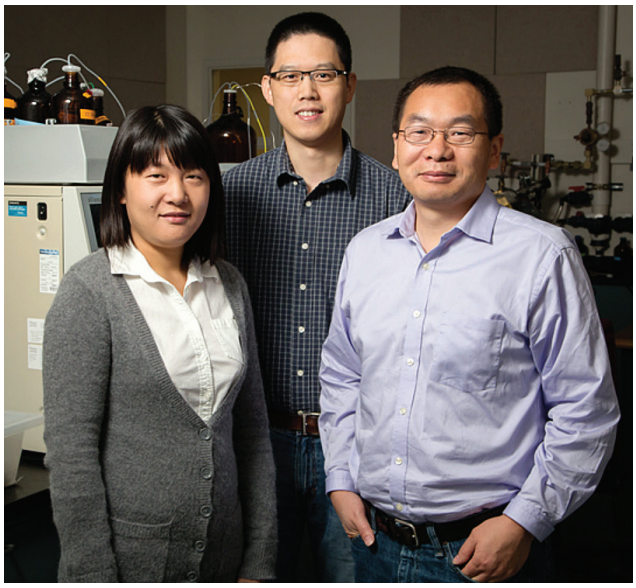
ISTC researchers report that wood-biochar supercapacitors can produce as much power as today's activated-carbon supercapacitors at a fraction of the cost – and with environmentally friendly results. Their study was published in the journal Electrochimica Acta in November.

The article "Highly Ordered Macroporous Woody Biochar with Ultra-high Carbon Content as Supercapacitor Electrodes" by ISTC researchers Junhua Jiang, Lei Zhang, Xinying Wang, Nancy Holm, Kishore Rajagopalan, and colleagues at the University of South Carolina attracted worldwide attention, ranking number one in the altmetric scores from altmetric.com for the journal over the last six months of 2013, even though it was not published until November.

"Supercapacitors are power devices very similar to batteries," said study leader Jiang, a senior research engineer at ISTC. While batteries rely on chemical reactions to produce sustained electrical energy, supercapacitors collect charged ions on their electrodes (in this case, the biochar), and quickly release those ions during discharge. This allows them to supply energy in short, powerful bursts – during a camera flash, for example, or in response to peak demand on the energy grid, Jiang explained.

"Supercapacitors are ideal for applications needing instant power and can even provide constant power—like batteries, but at lower cost," he said. They are useful in transportation, electronics and solar- and wind-power energy storage and distribution.

Many of today's supercapacitors use activated carbon – usually from a fossil-fuel source, Jiang said. For his biochar supercapacitors, any kind of wood—including white birch, white pine and red cedar—can be used and made into biochar by pyrolysis, a thermo-chemical method of heating materials in a low-oxygen chamber. In addition to the novel use of biochar in supercapacitors, the processing employed is expected to have less environmental impact compared to current methods of manufacture. See more biochar research on the next page.



Researchers Lei Zhang, above left, and Xinying Wang, center, with Junhua Jiang, a senior research engineer at the Illinois Sustainable Technology Center, are developing high-performance supercapacitors using wood biochar (below).

Marks of Excellence

Publications

Paul Francisco. "Unvented combustion." ASHRAE Journal. April 2013, Vol. 55 Issue 4, p 64-66.

Paul Francisco. "Paul Francisco views ventilation as a quality of life issue." Oak Ridge Institute for Science and Education, "Weatherization Training and Technical Assistance E-note" column.

Junhua Jiang, Xinying Wang, and **Lei Zhang**. "Nanoporous gold microelectrode prepared from potential modulated electrochemical alloying-dealloying in ionic liquid." Electrochimica Acta, (2013), volume 111, pp. 114-119, DOI information: 10.1016/j.electacta.2013.07.196.

Junhua Jiang, John Scott and Xinhuai Ye (ISGS). "Enhancing CO tolerance of platinum-ruthenium with polyoxometalate based on a triple-functional mechanism." ECS Electrochemistry Letters 2 (2013) F51-F53. DOI: 10.1149/2.006307eel.

D. Ramachandran, **N. Rajagopalan**, T. Strathmann, and V. Singh. "Use of treated effluent in ethanol production from cellulose." Biomass and Bioenergy, 56 (2013), 22-28.

B. Drury**, J. Scott**, E.J. Rosi-Marshall, and J.J. Kelly. "Triclosan exposure increases triclosan resistance and influences taxonomic composition of benthic bacterial communities." Environmental Science & Technology. DOI: 10.1021/es401919k

Joy Scrogum. "Why younger minds will solve the e-waste crisis." GreenBiz.com P2 Impact column.

Shailesh N. Shah, Osvaldo K. Iha, Flávio C. S. C. Alves, **B. K. Sharma**, Sevim Z. Erhan, and Paulo A. Z. Suarez. "Potential application of turnip oil (*Raphanus sativus L.*) for bio-diesel production: Physical–chemical properties of neat oil, bio-fuels and their blends with ultra-low sulphur diesel (ULSD)." Bioenerg. Res. 2013, 6(2), 841-850.

Mai Pham, Lance Schideman, **B.K. Sharma**, Yuanhui Zhang, and Wan-Ting Chen. "Effects of hydrothermal liquefaction on the fate of bioactive contaminants in manure and algal feedstocks." Bioresource Technology. 2013, Volume 149, pp 126-135.

Xiaolin Li, **Wei Zheng**, and Walton R. Kelly. "Occurrence and removal of pharmaceutical and hormone contaminants in rural wastewater treatment lagoons." Science of the Total Environment. 2013, 445-446:22-38.

Wei Zheng, Katie Witkin, Kishore Rajagopalan, and **B. K. Sharma**. "Complete utilization of spent coffee grounds to produce bio-diesel, bio-oil, and biochar," with colleagues from

Continued on page 32

Other Biochar Research

Pyrolysis of biomass produces bio-oils, bio-gas, and between 30-40 percent biochar, depending on the production conditions, especially temperature and reaction time utilized in the heating process. In addition to their research on biochar supercapacitors, there has been a growing interest in biochar in the past five years for use as a soil amendment, especially in poor soil conditions where it has been shown to increase soil fertility and to help retain nutrients and water.

ISTC staff have been investigating the usefulness of biochar from several directions. For instance, ISTC researcher Wei Zheng and visiting scientist Ling Zhao (Shanghai Jiao Tong University) are pioneering additives to include with the biomass feedstock used to make biochar to improve the biochar's carbon sequestration capacity and increase the chemical and biological stability of the "designer" biochar in soils. Specialized biochar formulations are also being explored as soil amendments to decrease nitrous oxide emissions from soils and reduce chemical fertilizer runoff.

In addition, a research team of Nancy Holm, Elizabeth Luber, and B.K. Sharma collaborated with Kurt Spokas of USDA-ARS-St. Paul on a recently completed study of the chemical, biological, and physical properties of ten different soils found in Illinois when mixed with biochar at three concentrations (zero percent, one percent, and five percent by weight). Biochar was made from three feedstocks (hardwood; corn stover; and *Miscanthus*) using three production methods. This work was supported by the Russell and Helen Dilworth Memorial Fund at U of I.

Biochar reduced N_2O emissions from the soils, however, biochar additions did not have a significant impact on CH_4 oxidation activity. Changes in microbial communities under the various conditions in the study are currently being determined in collaboration with John Kelly of Loyola University-Chicago to compare those changes to the changes in greenhouse gas emissions that were observed. Related studies are exploring the bioaccessibility of PAH (polycyclic aromatic hydrocarbon) contaminants in biochar and are discussed on page 10.

the U of I Department of Civil and Environmental Engineering, and the Agricultural Research Service, of the U.S. Department of Agriculture. ACS Sustainable Chem. Eng., 2013, 1 (10), pp 1286–1294.

D.R. Vardon, Bryan R. Moser, **Wei Zheng**, K. Witkin, Roque Evangelista, T.J. Strathmann, **N. Rajagopalan**, and **B.K. Sharma**. "Complete utilization of spent coffee grounds to produce biodiesel, bio-oil and biochar." ACS Sustainable Chem. Eng., 2013, 1 (10), pp 1286–1294.

Wei Zheng, Yonghong Zou, Xiaolin Li, and Michael L. Machesky. "Fate of estrogen conjugate 17α-estradiol-3-sulfate in dairy wastewater: Comparison of aerobic and anaerobic degradation and metabolite formation." Journal of Hazardous Materials, 2013, 258-259: 109-115.

Y. Zou, E.R. Christensen, and A.Li. "Characteristic pattern analysis of polybromodiphenyl ethers in Great Lakes sediments: a combination of eigenspace projection and positive matrix factorization analysis." Environmetrics 2013, 24(1):41-50.

Honors

Paul Francisco was appointed vice-chair of ASHRAE's Environmental Health Committee.

Paul Francisco was named chair of the ASHRAE Standard 62.2 committee on residential ventilation and indoor air quality.

Junhua Jiang was co-inventor of patent number 8,398,842 "Electrochemical process for the production of nitrogen-fertilizers," issued by the U.S. Patent and Trademark Office.

Dan Marsch and **Mike Springman** accepted, on behalf of the TAP program, the National Pollution Prevention Roundtable's Most Valuable Pollution Prevention Award (MVP2) for ISTC's Illinois Conservation of Resources and Energy (ICORE) project.

William Rose was named a fellow of ASHRAE, earned through achievement as a researcher, designer, educator or engineering executive. ASHRAE is an international technical society organized to advance the arts and sciences of heating, ventilation, air-conditioning and refrigeration.

Joy Scrogum and **William Bullock** (U of I Industrial Design professor and affiliated faculty scientist at ISTC), were guest editors for a special issue of the journal Challenges entitled "Electronic Waste—Impact, Policy and Green Design."

B.K. Sharma was named Associate Editor of the Journal of Surfactants and Detergents, a publication of the American Oil Chemists' Society published by Springer Verlag, Germany.

Wei Zheng was named Associate Editor for the Journal of Environmental Quality published by the Soil Science Society of America, the American Society of Agronomy, and the Crop Science Society of America.

Grants

Laura Barnes received $96,816 from U.S. EPA to continue funding the Great Lakes Regional Pollution Prevention Roundtable (GLRPPR) as a Pollution Prevention Information Network regional information center.

Jeffrey Gordon was awarded $85,602 for "IDPH CLEAR-WIN Program – Year 2 funding" by the Illinois Department of Public Health. The CLEAR-WIN program is a window replacement program to remove a major source of lead dust from older homes.

Paul Francisco was awarded $174,539 for "Transport of Contaminants from Garage Attached or Integral to Low-rise Residential Buildings" by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

Paul Francisco was awarded $747,566 from the U.S. Department of Housing and Urban Development for a three-year study on "Building Assessment of Radon/Moisture Reduction w/ Energy Retrofits (The BARRIER Study)."

Paul Francisco received $972,888 for the "Illinois Home Weatherization Assistance Program" (IHWAP) from the Illinois Department of Commerce and Economic Opportunity (IDCEO).

Paul Francisco is part of a team that was selected in a competitive RFQ process to provide Residential Building Science Technical Support to the California Energy Commission.

2013 ISTC Publications

Laura Barnes produced "**The Social Media Best Practices LibGuide**," developed as a tool for the regional centers in the Pollution Prevention Resource Exchange to share social media best practices and resources.

ISTC\HWRF Research Report (RR – 122) on "**Risks to Birds in the Lake Calumet Region from Contaminated Emergent Aquatic Insects**" was published on ISTC's web site. Authors: Soucek, David J.; Levengood, Jeffrey M.; Gallo, Sue; Hill, Walter R.; Bordson, Gary O.; Talbott, Jonathan L.

ISTC\HWRF Technical Report (TR-049) on "**Use of Treated Effluent Water in Cellulosic Ethanol Production**" was published on ISTC's web site. Authors: Ramchandran, D., Singh, V., Rajagopalan, N., and Strathmann, T.

ISTC\HWRF Technical Report (TR- 050) on "**Efficiency Performance Contracting for Smaller Manufacturers: Progress in the Metalworking Industry**" was published on ISTC's web site. Author: Bierma, Thomas J.

ISTC Fact Sheet (TN 13-103) "**Forward Progress in Reducing Oily-Wastewater: A Forward Osmosis, Small-scale Pilot at a Metal Fabricator**." Author: Marsch, Dan.

2013 ISTC Sustainable Technology Seminar Series

Jan. 17— Susan Mazur-Stommen, director of Behavior and Human Dimensions Program at the American Council for an Energy-Efficient Economy, and **Laura Barnes**, Great Lakes Regional Pollution Prevention Roundtable, "Beyond Energy Efficiency: Behavior Change Tactics for the Pollution Prevention Community," in co-operation with the P_2R_x Resource Exchange.

Jan. 31— Kris Skrinak, President of adaptiveARC, Inc., "Cool Plasma Gasification."

Feb. 14— Fredrik Grondahl, associate professor at the KTH Royal Institute of Technology, Stockholm, Sweden, "Sustainable Use of Baltic Marine Resources and the Production of Bio-gas."

Feb. 28— Rob Martin and Hans Detweiler, Clean Line Energy Partners, LLC, Chicago, Illinois, "Rock Island Clean Line - Bringing Wind Energy to the Eastern U.S."

March 14— John Kelly, associate professor, Department of Biology, Loyola University Chicago, "Ecotoxicology of Antimicrobial Pharmaceutical and Personal Care Products in Illinois Rivers and Streams."

March 28— Michael Brown, executive director, Ecology Action Center and Community Solid Waste Coordinator, Normal, IL, "Ecology Action Center: Local Action Makes a World of Difference."

April 25— John Rogers, Lee J. Flory Founder Chair in Engineering Innovation, Professor of Materials Science and Engineering, Professor of Chemistry, and Director of F. Seitz Materials Research Laboratory, "Water Soluble Electronics."

Sept. 5— Fu Zhao, associate professor, School of Mechanical Engineering, Purdue University-West Lafayette, "Recycling of Liquid Crystal Displays for Maximum Resource Recovery."

Sept. 12— **Xinying Wang**, research engineer, ISTC, "Polymer-assisted Forward Osmosis for Desalination and Water Reuse."

Sept. 26— Jeff Mendez, global communications director, ERS International, "Upcycling of Electronics."

Oct. 3— Eric Benson, associate professor and chair, U of I Graphics Design Program, "Fields of Gold, Deckles, and Moulds: Fresh Press and Agri-Fiber Papers."

Oct. 10— **John Marlin**, research affiliate, ISTC, "Mud-to-Parks: Beneficial Use of Sediment as Reclaimed Topsoil in Illinois."

Oct. 24— Sam Weaver, president, Proton Power Inc., Lenoir City, TN, "Powering a Clean Tomorrow: Cheap Hydrogen from Biomass."

Oct. 31— Mark Taylor, assistant professor, U of I School of Architecture, "The U.S. Department of Energy's Solar Decathlon Competition and the Progress to Solar Ready Housing."

Nov. 7— Sherri Mason, associate professor of chemistry, SUNY Fredonia, NY, "Great Lakes Plastic Pollution Survey 2012."

Nov. 14— Mike Hoadley, founder of www.FEWZION.biz, Chicago, "Challenges in Vertical Farming and Controlled Environments Agriculture."

Dec. 5— **Joy Scrogum** and **Nancy Holm**, Sustainable Electronics Initiative co-coordinators, ISTC, "2013 International Sustainable Electronics Competition Awards."

Nancy Holm and Eve Hargrave (ISAS) received a $3,000 grant from U of I Office of Public Engagement for the 2013 Naturally Illinois Expo for the Prairie Research Institute.

Nancy Holm and **B.K. Sharma** received $41,000 from the U of I Russell and Helen Dilworth Memorial Fund for their project entitled "Evaluation of Biochar Applications in 10 Illinois Soils."

Nancy Holm, Joy Scrogum, and **B.K. Sharma** received $6,000 from Hobi International to evaluate the feasibility of recycling plastic from used cellphones.

Deb Jacobson received $50,000 for "Zero-Waste to Landfill Characterization Survey," from the University of Illinois Facilities and Services Department.

John Marlin received $15,000 from the Illinois Conservation Foundation for continuing work on reclaiming sediment for beneficial reuse, commonly referred to as the Mud to Parks Program.

John Marlin received $33,602 in additional funding in 2013 from the Illinois Department of Natural Resources to support the beneficial reuse of sediment, commonly referred to as the Mud to Parks Program.

Kishore Rajagopalan and **B.K. Sharma** received $60,500 for "Feasibility of Energy Crop Production in IDOT Right of Ways – Year 2," from the Center for Advanced BioEnergy Research (IDOT).

Kishore Rajagopalan received $15,000 from Aquatech International Inc. for studies he is conducting related to Forward Osmosis.

Joy Scrogum received $4,518 from the U of I Office of Public Engagement to be used in 2014 for a project entitled "Sustainability Documentary Series and Resource Development."

B.K. Sharma and **Nancy Holm** received $15,000 from the U of I Russell and Helen Dilworth Memorial Fund for "A

Feasibility Study of On-Farm Utilization of Biomass for Energy and Biochar."

B.K. Sharma was awarded $165,155 by the Environmental Research and Education Fund for his project "Distributed Production of Ready-to-Use Gasoline/Diesel from Low-Value Waste Plastics."

B.K. Sharma and **Kishore Rajagopalan** received $25,000 for "Correlating the Compositional Dependence of *Miscanthus* Varieties on Yield of Polysaccharides and Bio-Oils," from U of I Plant Breeding Center and the Center for Advanced BioEnergy Research Seed Grant Funding Program.

B.K. Sharma and **Kishore Rajagopalan** received $25,000 from the U of I Agricultural & Biological Engineering department for a USDA-NIFA-funded project led by Lance Schideman of ABE titled "Characterizing The Fate And Transport of Chemicals of Emerging Concern (CECs) from Animal Manures During Waste-to-Energy Processes – Year 1."

Kishore Rajagopalan received funding of $114,222 from the Illinois Clean Coal Institute for "Fine Refuse and Ultrafine Coal Dewatering Utilizing an Osmotic Gradient."

Michael Springman was awarded $10,771 for "Performance of Due Diligence Assessments for Illinois Department of Military Affairs" by the Illinois Department of Military Affairs.

The **Technical Assistance Program** was awarded $109,000 by U.S. EPA Office of Pollution Prevention to support the "Illinois Conservation of Resources" (ICORE) program.

Presentations

Laura Barnes presented "Pollution Prevention Information: What's Out There and Where to Find It" at "P2 at the Crossroads" at the Indiana Partners in Pollution Prevention/National Pollution Prevention Roundtable joint conference in Plainfield, IN.

Laura Barnes, Great Lakes Regional Pollution Prevention Roundtable, "Beyond Energy Efficiency: Behavior Change Tactics for the Pollution Prevention Community," in co-operation with the P_2R_x Resource Exchange.

Laura Barnes and **Gary Miller** spoke at a session of the University of Illinois Extension Conference about the services of the Prairie Research Institute and ISTC.

Laura Barnes presented a webinar titled "Greening Your Library: Sustainable Practices for a New Generation" for the Special Libraries Association Illinois Chapter.

William Bullock presented "New Uses for Electronic Wastes" at the Reverse Logistics Association (RLA) Conference & Expo in Las Vegas, NV.

Sriraam Chandrasekaran presented "Research Update" at the Illinois Biochar Group fall meeting in Peoria, IL.

Sriraam R. Chandrasekaran, **Dheeptha Murali**, **B.K Sharma**, and **Kishore Rajagopalan** presented "Graphene Synthesis from Biochar Using Wet Chemical Treatment Process" at the Interdisciplinary Symposium on Advanced Nano/Biosystems: Design, Fabrication, and Characterization in Urbana, IL.

Paul Francisco presented "Performance of Duct Leakage Test Methods: When to Use Which and Why," at the 2013 AIVC Airtightness Workshop held in Washington, D.C.

Paul Francisco was a member of the organizing committee and co-chair of the Residential Track for the IAQ 2013 conference sponsored by ASHRAE in Vancouver, BC.

Nancy Holm presented a poster entitled "Evaluation of biochar applications in 10 Illinois soils" at the 2013 USBI North American Biochar Symposium held in Amherst, Mass. The poster was authored by **Nancy Holm, B.K. Sharma, Elizabeth Luber** along with Kurt Spokas (USDA) and Lacey Walsh (ISU).

Nancy Holm and **Elizabeth Luber** presented "Naturally Illinois Expo: Bringing Science Education to the Community" at the 2013 Midwest Environmental Education Conference in Iowa City, IA.

Nancy Holm and **Joy Scrogum** participated as part of a session entitled "Environmental Impacts of Electronic Technologies: The Search for Sustainable Electronics" for the Division of Environmental Chemistry at the 246th American Chemical Society (ACS) National Meeting and Exposition in Indianapolis, IN. Scrogum presented an "Overview of the Sustainable Electronics Initiative at the University of Illinois at Urbana-Champaign."

Nancy Holm and Kurt Spokas (USDA/ARS), presented "Evaluation of Biochar Applications in 10 Illinois Soils," at the Illinois Biochar Group fall meeting in Peoria, IL.

Paul Anderson (ChipEnergy) and **Nancy Holm** presented "Summary of the 2013 North American Biochar Symposium @ UMass Amherst," at the Illinois Biochar Group fall meeting in Peoria, IL.

Junhua Jiang presented "Progress on Biochar Supercapacitors," at the Midwest Biochar Conference in Champaign, IL.

John Marlin presented "The Use of Reclaimed Topsoil from Rivers and Lakes," to the Environmental Law Section Council of the Illinois State Bar Association in Springfield, IL.

John Marlin gave four presentations on native Illinois plants and use in the urban landscape to the East Central Illinois Master Naturalists, the Champaign County Master Gardeners, the Champaign County Design and Conservation Forum, and students at Lincoln Avenue Residence Hall.

John Marlin presented "Mud to Parks: Beneficial Use of Sediment as Reclaimed Topsoil" as part of the ISTC Sustainable Seminar series.

Zach Merrin presented a poster entitled "Measured Impact of Ventilation Rate Determination Strategy on IAQ Parameters" at the IAQ2013 Conference in Vancouver, BC.

Kishore Rajagopalan and V. Singh presented "Reducing Water Consumption in Ethanol Production" at New Technologies in Ethanol Production workshop course in Champaign, IL.

Kishore Rajagopalan presented "Effluent for Bio-fuels Production" at the International Starch Conference in Champaign, IL.

John Scott presented "PAH Content of Corn Stover Biochar Produced by Slow Pyrolysis at Three Different Temperatures," at the Illinois Biochar Group spring meeting in Champaign, IL.

Joy Scrogum presented a webinar on the Sustainable Electronics Initiative and its relevance to green university and college efforts to the Green Universities and Colleges

Subcommittee (GUCS) of the Illinois Green Governments Coordinating Council (GGCC).

B.K. Sharma, Bryan R. Moser, and **Kishore Rajagopalan** presented "Fuels from Pyrolysis of Waste Plastic," at the Division of Energy and Fuels: Frontiers in Energy Conversion and Fuel Production session at the 246th American Chemical Society National Meeting in Indianapolis, IN.

B.K. Sharma, **John Scott**, **Dheeptha Murali,** Richard A. Larson, and Karen A. Marley presented "Lignin-derived Antioxidants for Fatty Acid Methyl Esters," at the Division of Energy and Fuels: Fuels, Chemicals, Materials, and Energy from Coal, Natural Gas, Oil Shale, and other Natural Resources session at the 246th American Chemical Society National Meeting, Indianapolis, IN.

D. R. Vardon, **B. K. Sharma**, H. Jaramillo and T. J. Strathmann presented "Hydrothermal Catalytic Deoxygenation of Fatty Acids With *In Situ* Hydrogen Production from Glycerol Using Pt/C and Pt-Re/C catalysts" at the 246th American Chemical Society National Meeting in Indianapolis, IN.

D. Kim, D.R. Vardon, **B.K. Sharma**, and T. J. Strathmann presented "Hydrothermal catalytic conversion of waste vegetable oil without external hydrogen addition" at the 246th American Chemical Society National Meeting, Indianapolis, IN.

S. Leow, I. Bradley, D.R. Vardon, **B.K. Sharma**, J.S. Guest, and T.J. Strathmann presented "Hydrothermal Liquefaction of *Chlamydomonas reinhardtii*: Influence of Varying Cell Composition on Liquid Fuel Yield and Quality" at the Division of Energy and Fuels: Biomass and Biotechnologies for Energy session at the 246th American Chemical Society National Meeting in Indianapolis, IN.

T.J. Strathmann, D.R. Vardon, S. Leow, I. Bradley, D. Kim, J.S. Guest, and **B.K. Sharma** presented "Hydrothermal Conversion of Microalgae and Other 'Wet' Biomass Wastes to Liquid Hydrocarbon Fuels" at the 2013 AEESP 50th Anniversary Conference, Colorado School of Mines in Golden, CO.

B.K. Sharma presented "Biochar Studies at ISTC" at the Illinois Biochar Group spring meeting in Champaign, IL.

Xinying Wang, V.A. Patel, V. Namboodiri, **N. Rajagopalan** presented "Polymer-assisted Forward Osmosis" at the 17th Annual WateReuse Conference in Phoenix, AZ.

Xinying Wang, Hafiz Salih, N. Rajagopalan, and V. Namboodiri presented, "Polymer-assisted Forward Osmosis For Desalination And Water Reuse" at the 28th Water Reuse Symposium in Denver, CO.

Ling Zhao (visiting researcher from Shanghai Jiaotong University, China) presented "Strengthening of Carbon Sequestration during Biochar Production by Chemical Modification" at the Illinois Biochar Group fall meeting in Peoria, IL.

Wei Zheng presented a poster entitled "Synergistic Effect of Combined Application of Biochar and Nitrogen Fertilizer" at the Midwest Biochar Conference in Champaign, IL based on research with **B.K. Sharma**, **Kishore Rajagopalan**, and **Nancy Holm**.

Wei Zheng presented "From Waste Biomass to Biochar: A Potential E3 (Energy, Environmental, Economic) Profit Strategy" to the U of I chapter of the American Chemistry Society during National Chemistry Week.

Wei Zheng and Michael Machesky presented "Environmental Fate and Transport Of Steroid Hormones and Veterinary Antibiotics Derived from Animal Farms" at the 68th Soil and Water Conservation Society Annual Conference in Reno, NV.

Wei Zheng, Kelsey Wiles, and **Nancy Holm** presented "Uptake, Translocation, and Accumulation of Pharmaceutical and Hormone Contaminants in Vegetables," at the 246th American Chemical Society National Meeting in Indianapolis, IN.

Wei Zheng, Yonghong Zou, and Michael L. Machesky presented "Environmental Fate of Pharmaceuticals and Hormones Derived from Water Reuse," at the 246th American Chemical Society National Meeting in Indianapolis, IN.

Yonghong Zou presented a poster on "Manure Colloids Facilitated Transport of Veterinary Antibiotic Florfenicol in Soils" at the University of Illinois' Third Annual Postdoctoral Research Symposium.

International Impacts

Paul Francisco presented "Ventilation and IAQ in Homes Receiving Energy Efficiency Retrofits" at the 2013 ISIAQ/ISES/ISEE Environmental Health Conference in Basel, Switzerland.

Fredrik Grondahl and Maria Malmstrom of KTH Division of Industrial Ecology (Royal Institute of Technology, Stockholm) visited ISTC to continue their collaboration with **B.K. Sharma** and **Srirupa Ganguly** on bioenergy, bio-treatment of saline waters, mariculture, and aquaculture.

Zach Merrin spent a month in Palwal, India (near New Delhi) on a research project investigating the impact of solid fuel-based cook stove emissions on climate change, in collaboration with the U of I Department of Civil and Environmental Engineering.

Zach Merrin presented a poster, "Measured Impact of Ventilation Rate Determination Strategy on IAQ Parameters" at the IAQ2013 conference in Vancouver, BC.

Joe Pickowitz traveled to Paulette, Haiti, in December to continue collaboration to develop a bio-fuel production facility. (See page 27.)

The Sustainable Electronics International Design Competition awarded prizes to four teams of college students from Australia, Mexico and Canada. (See page 6.)

B.K. Sharma presented "Novel Conversion Technologies" at the 2014 International Bioenergy Conference, March 11-13 in Manchester Central Convention Complex, Manchester, England, U.K.

Public Engagement/Outreach

Laura Barnes organized the 2013 Great Lakes Regional Pollution Prevention Roundtable Annual Meeting in Plainfield, IN in September.

ISTC held a mini-symposium in October on the role of algae in future commercial applications for food, feed, bio-based materials, and bioenergy. **Srirupa Ganguly** of ISTC, Harry Dankowicz of the U of I Department of Mechanical Sciences and Engineering along with Fredrik Grondahl and Maria Malmstrom of Division of Industrial Ecology at KTH (Royal Institute of Technology, Stockholm) presented talks and discussed their efforts

Gary Miller, Institute associate executive director, and David Thomas, acting director of ISTC were honored at the Governor's Sustainability Award Ceremony for their leadership in the establishment of the award program.

in international collaboration on biotreatment of saline waters and mariculture and aquaculture projects.

ISTC hosted a group of first-year engineering students and freshman English students for information sessions on sustainable technologies.

ISTC hosted a screening of "Troubled Waters: A Mississippi River Story," and a presentation about water quality issues by George Czapar of the Illinois State Water Survey in October as part of U of I's Sustainability Week. The event illustrated the water quality problems caused by agricultural practices and policies in Illinois and throughout the Mississippi River basin.

ISTC participated with informational displays on recycling, waste reduction and electronic waste in the U of I's Sustainability Week in October.

ISTC staff participated in the Naturally Illinois Expo event, a joint activity of all five divisions of the Prairie Research Institute.

ISTC organized and hosted the first Midwest Biochar Conference on June 14, 2013. There were 20 oral presentations and 17 posters. **Nancy Holm** and **Elizabeth Luber** were co-organizers of the event. (See p. 7)

Nancy Holm, **Elizabeth Luber**, **Joy Scrogum**, and **Jim Dexter** provided information on ISTC's research and sustainability activities during Science at the Market events at Urbana's Market at the Square on Aug. 24 and Sept. 14.

Nancy Holm, Kirsten Walker, and **Elizabeth Luber** organized the first Prairie Research Institute Science Camp for rising juniors and seniors in high school and recent graduates. The camp was held July 15 -19. The students spent one day at each survey learning about the many different science topics. At ISTC, the students explored various feedstocks for producing bio-fuels and tested the fuel in a go-cart. They also used different investigative techniques to identify mystery compounds. **B.K. Sharma**, **Joe Pickowitz, John Scott,** and **Shijie (Moses) Leow** led the camp activities at ISTC. Twelve high school students from eight area high schools attended. The camp will be offered again July 21-25 in 2014.

Nancy Holm, Kirsten Walker, and **Seth Rients** represented ISTC at a booth at the "Green Fair" held on July 12 at the U of I Research Park. They provided information about ISTC's initiatives on zero waste and sustainable electronics as well as on other sustainable activities and research projects at ISTC.

Seth Rients, B.K. Sharma, Kirsten Walker, and **Nancy Holm** participated in the first Central Illinois Sustainability Fair held at Richland Community College in Decatur on June 8, 2013. They had exhibits about their work on sustainability in the areas of zero waste, storm water management, bio-fuels and bio-oils, biochar, and sustainable electronics.

Classes and Training

Paul Francisco taught the "Building Diagnostics" course for Illinois weatherization agency staff.

Jeff Gordon taught "Health and Safety" and "Quality Control Inspector" courses for Illinois weatherization agency staff.

Nancy Holm taught a fall semester course, "Sustainability in Action: Technology and Practice," (ENG 498) in collaboration with the U of I College of Engineering.

John C. Marlin taught a fall semester course, "Beneficial Reuse of Sediment: The Mud to Parks Field Experience" (NRES 285), through the U of I College of Agricultural, Consumer and Environmental Sciences.

Joy Scrogum and **Kirsten Walker** worked to plan a new spring course, "Sustainable Technology: Environmental and Social Impacts of Innovations" (ENG 498/TE 498/TE 298), in collaboration with the U of I College of Engineering, the Technology Entrepreneur Center, and the Innovation and Sustainability Living Learning Communities.

B.K. Sharma and **Joy Scrogum** were among the faculty for the GLAM camp (Girls Learning About Materials), a STEM outreach effort for high school girls at the U of I.

Wei Zheng participated in teaching a capstone course for animal science seniors for the College of Veterinary Medicine at the U of I.

Nancy Holm, assistant director, and David Thomas, acting director of ISTC congratulated associate director Kishore Rajagopalan upon his appointment as Illinois Pollution Prevention Scientist.

Outreach at ISTC

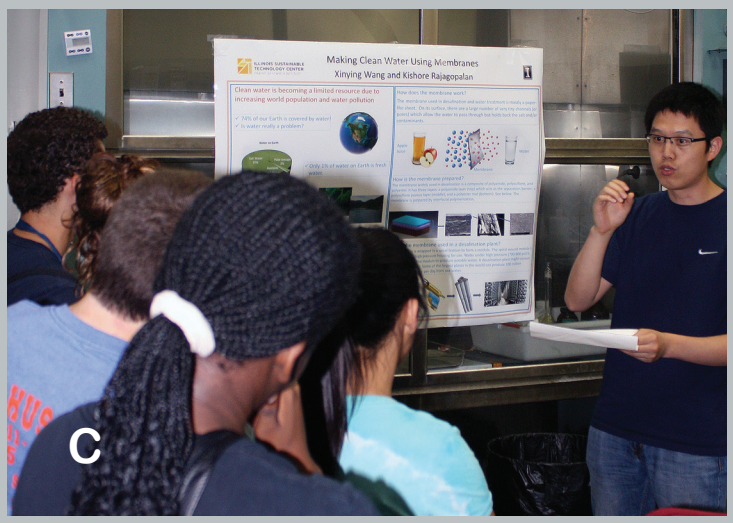
Outreach at ISTC has long been part of our mission as we provide information to the general public, students, researchers, businesses, industries, government officials, and other entities. We participated in the Prairie Research Institute's Naturally Illinois Expo event in March which had over 1,500 elementary- and middle school-aged students in attendance and over 1,000 other attendees viewing our seven ISTC exhibits (below) as well as 30-some other Institute exhibits.

We hosted over 20 seminars and a number of visitors from IL, the U.S., and abroad for tours of our laboratories. High school students enjoyed their day at ISTC as part of the first Prairie Research Institute Science Camp (right and center) in July.

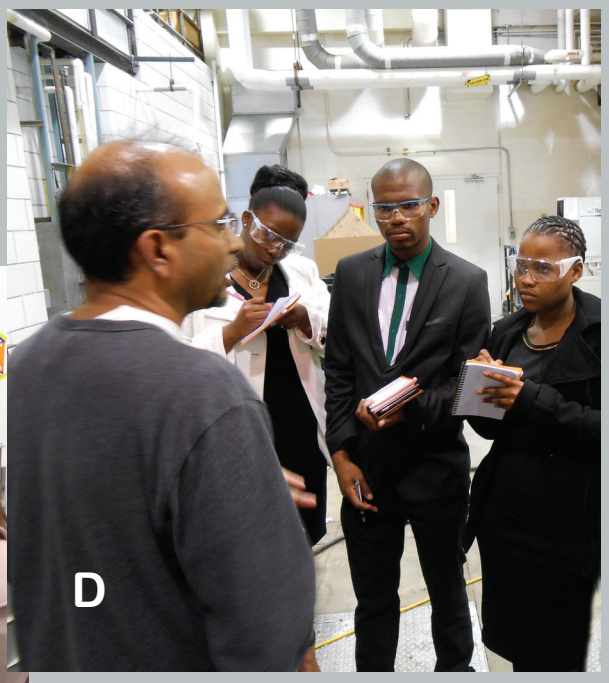
We provided information on sustainable living and our research at various sustainability fairs and talks on campus and in local communities as well as at regional, national, and international conferences. The Great Lakes Regional Pollution Prevention Roundtable we direct and our technical assistance group conducted outreach to businesses and agencies throughout the state and beyond.

The Institute developed a summer science camp for area high school students. During ISTC's portion of the week, students studied water contaminants and the production of bio-fuel and then drove a go-cart fueled with bio-fuel.

The Insitute's Naturally Illinois Expo provided hundreds of children the opportunity to learn about sustainability, resource conservation and careers in the sciences. A Public Engagement Grant from the U of I allowed curriculum resource boxes to be developed from the Expo and distributed to area schools.



Outreach takes many forms at ISTC. During 2013 the Center spread information about sustainability through special events, tours, and media coverage. (A) Seth Rients at U of I's Sustainability Week. (B) Elizabeth Luber at the Earth Week celebration on campus. (C) Xinying Wang speaks to freshman English students about desalinization research. (D) B.K. Sharma delivers a tour of Center laboratories for South African researchers. (E) U of I's Algae Club attends a symposium on an algae research collaboration between ISTC and KTH (Royal Institute of Technology, Stockholm). (F) Laura Barnes and Mike Springman help the U.S. EPA teach a pilot P2 training program. (G) Jennifer Deluhrey is interviewed about ISTC's plastic bags to fuel research. (H) Nancy Holm participates in Richland Community College's Sustainability Fair.



ISTC Advisory Board

John Abelson
Co-Director, Energy & Sustainability Engineering Initiative
Emeritus Professor, Dept. of Materials Science & Eng.
University of Illinois at Urbana-Champaign

Christine Anderson
Pollution Prevention Coordinator
U.S. EPA, Region 5

Stephen Bell
IGEN Interim Executive Director
College of Lake County

David Boulay
President, Illinois Manufacturing Extension Center
Bradley University

Larry Dawson
Deputy Director, Office of Energy Assistance
Illinois Department of Commerce & Economic Opportunity

Kevin Greene
Manager, Office of Pollution Prevention
Illinois Environmental Protection Agency

Alan Jirik
Vice President of Environmental Affairs
Ingredion Incorporated

Warren Lavey
Senior Fellow, Senior Attorney
Environmental Law & Policy Center
Adjunct Faculty, Department of Natural Resources and Environmental Sciences
University of Illinois at Urbana-Champaign

Tim Lindsey
Global Director of Sustainable Development
Caterpillar, Inc.

Will Maurer
Associate Professor
Illinois Institute of Technology

Brian McGuire
President
Tooling & Manufacturing Association

Caralynn Nowinski, MD
Associate VP for Innovation & Economic Development
Office of the Vice President for Research
University of Illinois at Urbana-Champaign

Jerry Peck
Associate Director of Government Affairs
Illinois Manufacturers' Association

Jean Pogge
Chief Executive Officer
Delta Institute

Todd Thornburg
Manager of Commercial & Industrial Programs ComEd

Jimmy Samartzis
MD – Global Environmental Affairs and Sustainability
United Airlines – WHQEN

Seth W. Snyder
Section Leader, Process Technology Research Energy Systems
Argonne National Laboratory

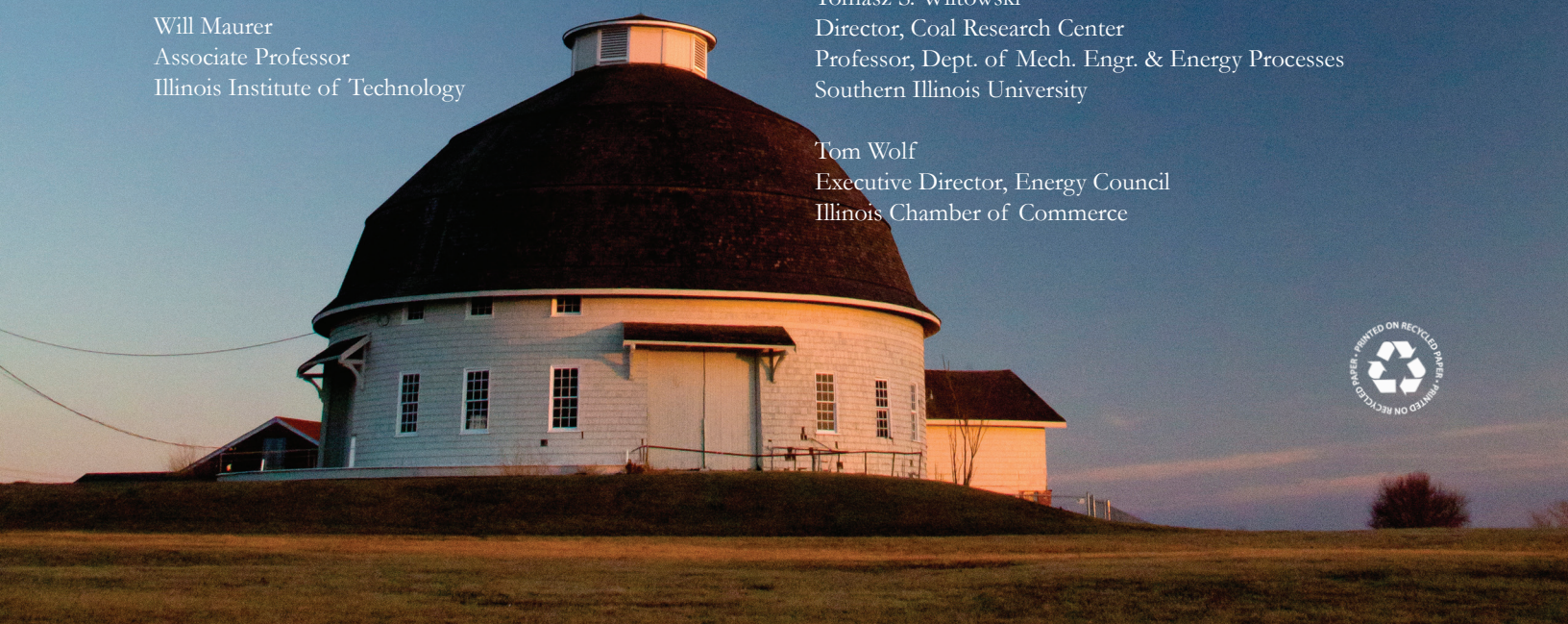
Deborah Stone
Director, Department of Environmental Control
Cook County

K.C. Ting
Professor and Head, Dept. of Ag. and Biological Eng.
University of Illinois at Urbana-Champaign

Phil Van Ness
Webber & Thies, P.C.

Tomasz S. Wiltowski
Director, Coal Research Center
Professor, Dept. of Mech. Engr. & Energy Processes
Southern Illinois University

Tom Wolf
Executive Director, Energy Council
Illinois Chamber of Commerce



ILLINOIS SUSTAINABLE
TECHNOLOGY CENTER
PRAIRIE RESEARCH INSTITUTE

1 Hazelwood Dr.
Champaign, IL 61820

istc.illinois.edu